Luther Burbank

### *Half Sweet, Half Sour Apple*

***This picture shows the curious effects that sometimes result from cross-fertilizing two fruits. Half of the stigmas of the flowers were self-fertilized and half cross-fertilized. As a rule cross-fertilization does not show its results immediately in the fruit, but only in the progeny; but in exceptional instances such as this the results are directly and surprisingly manifest.***

# LUTHER BURBANK

## HIS METHODS AND DISCOVERIES AND THEIR PRACTICAL APPLICATION

PREPARED FROM
HIS ORIGINAL FIELD NOTES
COVERING MORE THAN 100,000 EXPERIMENTS
MADE DURING FORTY YEARS DEVOTED
TO PLANT IMPROVEMENT

WITH THE ASSISTANCE OF
The Luther Burbank Society
AND ITS
ENTIRE MEMBERSHIP


UNDER THE EDITORIAL DIRECTION OF
John Whitson and Robert John
AND
Henry Smith Williams, M. D., LL. D.


## VOLUME IV

ILLUSTRATED WITH
105 DIRECT COLOR PHOTOGRAPH PRINTS PRODUCED BY A
NEW PROCESS DEVISED AND PERFECTED FOR
USE IN THESE VOLUMES


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# Volume IV—By Chapters

# Foreword to Volume IV

We begin, now, to take up with greater detail, practical combinations of method—particularly as applied toward producing new orchard fruits. In this volume Mr. Burbank has covered practically all the simple orchard fruits save the plum and the prune.

Although the purpose, here as before, is to be as specific as possible, yet the facts are carried through in narrative form, showing, always, how the actual method employed fits into the scheme of work as outlined in Volumes I, II and III.

From this volume the reader will glean much of practical interest and value from Mr. Burbank's experience with laying out orchards, to making orchards pay, and to the practical management of orchards—with an eye always to the bearing of Mr. Burbank's work upon the improvement of the human plant.

THE EDITORS.

## The Plumcot

*This remarkable fruit was produced by Mr. Burbank by hybridizing the Chinese plum and the apricot. Most plant breeders held that so wide a cross was impossible, and in point of fact the hybridization was not effected without difficulty. The story is told in detail in the text. The hybrid product is virtually a new species, of which Mr. Burbank has developed many varieties.*

# Quick Possibilities in Fruit Improvement

## Specific Needs, and How to Accomplish Them

THE old pear tree out there in the corner of your garden was perhaps planted by your father's father.

The twig you cut from it today may take root and become a thrifty tree that will bear fruit to gladden the hearts of your grandchildren long years after you are dead. And that possibility puts the tree on a very different footing as the friend and companion of man from that occupied even by the best-prized members of the company of forage plants and garden vegetables.

When you work with fruit trees you are making permanent records. You are building on a rock. You are reaching out your hands to future generations, and erecting a monument that will remain as a testimonial to your foresight and wisdom long after you are gone.

And doubtless this fact of the permanence of

the tree accounts in large measure for the interest with which almost anyone will take up the culture of fruits if given the opportunity. Not that we are always thinking of posterity; but one can develop an enthusiasm about the production of something having an element of permanency that does not attach to such transient things as annual or biennial plants.

The fruit tree in the old orchard is like an old friend when we get back to it. The mere view of it brings up reminiscences of our youth, and the tree that we planted in childhood may remain as a stimulus to us in old age.

There is no friendlier compact than that between man and the fruit tree.

It is an age-long compact withal. Not so ancient as the compact of bees and flowers—for as compared with the archaic and honorable order of insects man is a parvenu—but far older than human civilization none the less.

Indeed, it was probably the fruit tree, giving an example of fixity of habitat, that encouraged man to give up the life of a nomad and establish a fixed abode.

Not unlikely it was the evidence presented by the fruit tree that first suggested to man the possibility of raising a supply of foods from the soil, and thus lured him away from the precarious

*The Old Idea of an Orchard and the New*

***The center of the picture shows the new type of orchard—the trees so small that a good part of the fruit can be picked without the use of a ladder. At the right is the old type of orchard, in which much of the energy of the tree was allowed to go to the development of needless branches, making it difficult to care for the tree properly, and particularly difficult to gather the fruit.***

pursuits of the hunter and fisher and put him on the road to future greatness.

And all along the road of advancing civilization the friendship with the fruit tree has been kept up. Yet it is only in comparatively recent times, probably, that rapid progress has been made in aiding our coadjutors of the pomological world to step forward and better themselves as man had long ago bettered himself with their assistance, To be sure, our forebears developed many forms of fruit that were not lacking in palatability; but the great advances in the improvement of orchard fruits are matters of the nineteenth century.

Recent progress in this field has been almost as wonderful as progress in the fields of mechanics and electricity.

The orchard fruits of today that find their way to the markets are so different in size and quality from the fruits with which our grandparents were satisfied—even though some of them are grown on cions grafted on the old trees—as to seem to belong almost to different orders, certainly to different species from the fruit stocks from which they have been developed.

Yet what has been done is only the beginning. We speak of "perfected" fruits, and in a sense the word is justified, so conspicuous are the good

qualities of the new fruits as contrasted with the old. But no fruit has really been perfected, in the sense of having reached the limits of improvement.

There are numberless opportunities for betterment even in the case of the very finest varieties of fruits of every kind.

The successive chapters of the present volume will be devoted to specific suggestions as to the betterment of each of the important classes of orchard fruits. In the present chapter, it is my purpose to take a general survey of the field, pointing out various lines of betterment not so much with reference to any particular fruit, although we shall constantly draw our illustrations from specific fields, as with reference to the entire class of orchard fruits.

The suggestions here outlined are the result of lifelong association with trees of the orchard. Probably not less than half my experiments of every character have been conducted in connection with one form or another of fruit trees.

And a very large proportion of my most important new products, considered from an economic standpoint, have been products of the orchard.

### As to Mere Size

Almost the first thought that comes to one

who goes into the average orchard and looks about with a really observant eye is that orchard trees in general are not well-adapted to man's needs in the matter of size.

I have in mind certain orchards of New England and Long Island, for example, in which the apple trees seem to have done their very best to rival the elms and oaks in size. Their trunks and main central branches rise, barren of fruit-producing branches, to a height of twenty or even thirty feet.

The strength of the tree has gone to producing wood instead of fruit-bearing twigs. Such fruit as does appear is suspended so high that long ladders are required to reach it when it has ripened.

This is obviously all wrong. There is no reason why the apple tree should be permitted to grow high into the air even if it has the inherent propensity to do so. By proper trimming, the young tree can be made to assume a spreading form, so that it will bear most of its fruit within easy reach. Moreover, it is easily possible through selective breeding to develop an apple stock that will have no tendency to grow into tall, or otherwise ill-shaped trees, but will naturally take on the compact, low-growing habit that is to be desired in a fruit tree.

## A Perfect Apple

*This picture shows one of the many types of new crossbred apples that Mr. Burbank has developed. He considers this as representing practically an ideal form of fruit, and he urges that there is no reason why all the apples in the orchard should not conform to, or at least approximate, the ideal type. Selective breeding and intelligent supervision are of course required to accomplish this.*

What is true of the apple is equally true of its cousin the pear. This tree also has been permitted in the old-time orchards to develop the pernicious habit of too slender upright growth and undesirable tallness, too much like a wildling. These defects have been corrected with some of the newer varieties, to be sure, but these have not been introduced universally.

The same criticism applies to the cherry. Everyone knows how often this tree is seen growing in the New England dooryard, with trunk like that of the sturdiest oak, and with its inviting clusters of red fruit suspended at such a height as to be quite beyond reach of everyone but the birds.

A well-trained cherry should renounce this tantalizing habit and make its wares reasonably accessible to the wingless biped that has fostered it.

The other notable members of the company of orchard trees, namely the plum, peach, quince and orange, have in the main developed a more commendable habit of growth. Their trees are for the most part not too large, and the best varieties have a spreading form that leaves little to be desired. But some of these, and in particular the peach and orange, have other faults that urgently call for correction.

The peach in particular is a tender and short-lived tree, peculiarly subject to the attacks of insects and to fungoid pests.

Seemingly the developers of this luscious fruit have been so concerned to foster the remarkable qualities of the fruit itself that they have neglected the tree on which the fruit grows. So the peach orchard, instead of outlasting a human generation as it should, is an ephemeral growth, the individual trees of which are in good bearing only for a few years, after which they must be replaced.

The peach grower is always uprooting the dead trees in one part of his orchard and planting new ones in another.

### The Question of Stamina

Unfortunately the peach is so specialized that it will not thrive on any roots except its own. It should be possible, however—at least the project is one that invites the experimenter—to develop a more vigorous and longer-lived race of peaches. Something could doubtless be done by mere selection, taking cions for grafting or raising seedlings from the hardiest and most vigorous trees of the orchard. It has been shown that it is possible to hybridize the peach with its hardier relative the almond. Probably in successive generations there might be developed a hybrid stock of trees that would retain all the good qualities of the peach

and yet would be as long-lived and vigorous as the almond, and hardier and more resistant than either.

It is true that no very striking results have yet been produced by crossing almond and peach, though many unusually vigorous and rapid-growing trees have been produced which will far outgrow the most vigorous individuals of either species.

But hybridizing, followed by rigid and persistent selection, is a practical method that is still in its infancy. It is not so very long since orchardists in general, supported by technical botanists, denied the possibility of hybridizing different species.

My long series of varied experiments were perhaps more directly instrumental than any other influence in showing the fallacy of this belief. The reader will recall that I have in many instances interbred species belonging to different genera; and that the interbreeding of different species in my orchards and gardens is a commonplace. Yet it is still true that there are many cases in which there are seeming barriers erected between plants that obviously are closely related, which prevent the advantageous hybridizing and grafting of one species with another.

And the peach is a case in point. It accepts the

*The Ideal Peach—and Some Others*

*At the left, some peaches of the type developed by Mr. Burbank through crossbreeding. At the right, peaches of a type of which the average peach orchard furnishes only too many examples. There is no reason why the main crop of the orchard should not conform to the type of peaches at the left, if Mr. Burbank's methods of selection are followed out.*

pollen of its nearest relations (except the almond) unwillingly, and as yet no useful product has come of such union.

Yet the peach is not more isolated in this regard than its relative, the apricot, seemed to be until I was able, after many futile efforts, to break through the barriers and hybridize that fruit with the plum. The hybrid that resulted, named the plumcot, is virtually a new species. It combines the good qualities of both parents and is a very valuable addition to the list of orchard fruits. It seems not unlikely that some future experimenter will be able to effect a correspondingly useful hybridization of the peach; then the way will be open for the development of a race of peaches that will combine with the existing qualities of fruit production the qualities of hardiness and resistance to disease that the present peach tree so notably lacks.

### Big Fruit and Free Bearing

Size of fruit and prolific bearing are characteristics of such obvious desirability that they cannot be overlooked even by the tyro.

Yet the average amateur, who has a group of fruit trees in his garden or even a fair-sized orchard on his country place, is content to buy large, handsome, and well-seasoned fruits in the market, taking it for granted that his own trees

cannot be expected to supply similar products. But in point of fact it is well within the possibilities to produce good orchard fruits wherever the trees exist that produce any fruit at all. Conditions of soil and climate cannot, of course, be ignored. One cannot grow oranges in Canada or grapefruit in New England—as yet. But if you have apple trees or pears or plums or cherries that bear fruit, it is a matter of your own choice whether they shall bear good fruit or bad.

All that is necessary is that you should send to some reputable nurseryman or orchardist and secure cions of good variety for grafting on your trees.

All apple trees are closely related, the cultivated varieties being without exception of mixed strains. The same is true of pears and plums and cherries. In each case you may graft on your native stock cions of any variety of the same species, or a dozen or a score of different varieties, and, if the work is done properly and at the right season, the new twigs will soon become a part of the old tree as regards vitality and capacity for growth and fruiting; but—as we have learned in earlier chapters—they will retain their inherent hereditary tendencies as to quality of fruit.

Growing side by side, on the same tree, you may have summer apples and winter apples, sweet

apples and sour, green varieties and red varieties. And all this without any necessity for experimentation on your part. You need have no knowledge of plant breeding except an understanding of the simple technique of grafting.

The professional experimenters have supplied the material; you have but to avail yourself of the results of their work.

Of course, if you wish to go a step farther there are inviting fields that you may enter. With the materials furnished by a single old apple tree you may become a plant developer. You may plant the seed of any choice apple purchased in the market and from the seedlings you will develop an interesting variety of fruits, some of which may seem to you better than any existing varieties.

We have already caught glimpses, in the outlines of my work already given, of the possibilities of the development of various orchard fruits as to size and flavor and other desirable qualities.

If you desire to try your hand at similar improvement either of the fruit now growing on your ungrafted trees, or of that growing on cions of improved varieties, it will require only reasonable attention to the principles already outlined in earlier chapters of this work, together with a fair degree of patience and persistency, to insure some measure of success.

There is one additional hint that it might not be amiss to emphasize. In selecting seed for planting, it is desirable, of course, to select the largest and best specimens. But it should be recalled that the real test of quality in a tree is not the production of exceptional individual fruits, but the size of the average fruit that it bears.

Exceptional conditions of nutrition may cause a single apple to grow very large on a limb that as a rule produces only fruit of meager proportions. Seedlings from this exceptional fruit do not inherit the exceptional quality of their parent.

It is the germ plasm of the tree itself that counts. Seed from a very small apple of a good variety will produce better offspring than the seed of a very much larger individual specimen of a poor variety; so it is far better to select the poorest fruit of a good variety rather than the best of an ordinary variety.

This principle should be borne in mind in undertaking plant development of any kind, not merely with reference to orchard fruits. It is the inherent properties of the plant organism as a whole that will determine the average character of the fruit.

### Breeding for Quality

As to the special qualities of fruit that call for improvement, details, of course, differ with dif-

ferent species. We have seen that sugar content is an all-important item in the case of the prune; and that sweetness and flavor and color are matters of importance in the case of the cherry. We have also seen with what relative ease varieties may be developed that surpass their parent forms in these regards.

An interesting illustration of the possibility of breeding new qualities into a fruit or accentuating old ones, to which reference has not hitherto been made, is manifested by one of my new cherries, which, through selective breeding, became so sweet that its sugar content acts as a preservative, quite as in the case of the sugar prune.

These cherries, instead of decaying rapidly after ripening, dry on the tree in a state of perfect preservation. This particular feature is of no present commercial value, but the case illustrates the possibility of altering the inherent qualities of a fruit, and of doing this in the course of a few generations through systematic selection.

The same thing is illustrated by another of my cherries which, by careful attention to a combination of qualities that would ordinarily be quite overlooked, had its stem so strongly anchored to the stone that when the fruit is picked the flesh tears away leaving stem and stone on the tree.

Now it will be recalled that, in the case of the

prune, it is a serious defect to have the fruit so firmly attached to the stem that it clings to the tree after ripening. A prune must drop of its own accord when ripe or the prune dealer will have none of it. But the quality that would make a prune commercially worthless, when accentuated in the cherry, becomes a mark of possible exceptional value. The cherry that leaves its stone on the tree might conceivably fill a special purpose. So this variation in the inherent properties of the cherry might produce a new race of commercial value to meet an exceptional need.

It requires but little ingenuity to suggest possible developments that would similarly give added value to the fruits of various species.

For example, there is the matter of color in the pear. Unlike most other fruits, this one, as everyone knows, is for the most part lacking in the brilliant color that purchasers of fruit in the market usually find so attractive. But there is no reason why pears of various brilliant and attractive colors should not be developed just as colored apples have been developed.

Our native crab apple is dull greenish brown or dull red, and unattractive in color even when ripe. Of course this is not the direct progenitor of the cultivated apple, but it obviously belongs to a closely related strain, and it shows us the apple

## Getting Color into the Pear

*The ordinary pear, in its better varieties, is as large as can be desired, and its shape is regarded by many fruit growers as ideal. But hitherto the pear has for the most part lacked the color which gives such attractiveness to many varieties of apples. Mr. Burbank has been experimenting, however, in the production of pears with richly colored skins, as the example at the right shows, as contrasted with the ordinary one at the left, one of the results of this experiment.*

in a state of nature and gives us a clue as to what qualities of fruit are advantageous to the apple itself, and what ones have been bred into the stock to meet the demands of the fruit developer. So the fact that the wild crab apple is dull in color suggests that the variously pigmented coat of the cultivated apple is an artificial product, not primarily beneficial to the plant itself, that man has developed through selection.

It is not unlikely that the relatively thin skin of the cultivated apple, coincidentally developed, makes pigmentation desirable, to protect the tissues of the fruit from too much sunlight. The fact that many apples redden where exposed to the sun, and remain green where protected by the shadow of a branch or leaf, suggests that such is the case.

Be that as it may, the point I wish to emphasize at the moment is that the pigmented coat of the apple has been produced mostly by unconscious artificial selection. There can be no doubt that the pear could be similarly given a brightly colored skin should anyone care to take the trouble to make the experiment in selective breeding.

Indeed, a few varieties of partly red pears have been developed, and have proved a valuable novelty in the market. Other and better varieties, variously tinted, should follow.

It has been suggested that a globular or apple-shaped pear with a short stem would be acceptable to the packers because it would crate more compactly and carry better than the ordinary pear. But this would rob the fruit of one of its distinctive characters, so on the whole the change would probably not be an improvement. In the matter of size, also, it would appear that the pear, in its best varieties, has attained a maximum development.

To make it much larger would be detrimental, as it would probably be torn from the tree by the wind. Even now some varieties are so large that they break away from the tree before ripening, and so these varieties are avoided. The Beurre Clairgeau, one of the best of pears, is little grown for this very reason.

But in matter of flavor there is still opportunity for indefinite variation. Some European cultivators have recently produced remarkably pleasing and varied flavors in this fruit. An illustration of how the flavor of a fruit may be radically modified is furnished by my Apple Plum, which, while retaining the characteristic attributes of its race, curiously simulates the apple in the matter of form and even in taste and texture.

Another instance is my Bartlett plum, which out-Bartletts the Bartlett pear in its own peculiar

quality and flavor. Yet others are the Pineapple quince, which has the flavor of the pineapple itself, and the Sunberry, which has the exact flavor of the blueberry intensified.

Corresponding modifications of the pear as well as of all other fruits lie within reach of the patient experimenter.

### Leaving Out the Core

But perhaps the most inviting field of all, in connection with the possible development of orchard fruits, is that having to do not with the form or texture or flavor of the pulp but with the seed of the fruit.

Of course it must not be overlooked that, from the standpoint of the fruit itself, or rather from the standpoint of the tree on which it grows, the seed is the only really essential part of the fruit. All of the embellishment of juicy pulp and highly pigmented skin is but the lure put forth by the plant on behalf of the seed, in the interests of self-preservation.

The really essential part of the entire structure is but an infinitesimal cell lodged at the heart of each kernel of the seed.

Indeed, we may go even one step further, with the aid of the microscope, and say that the nucleus of a single cell, born of the union of the nuclei of two germ cells, is the really important part not

## The Apricot

*The apricot is a very luscious fruit, and one that is highly prized. The great difficulty in growing it is that it is not hardy—chiefly because the blossoms are likely to be nipped by the spring frosts. Mr. Burbank has experimented in the development of varieties of apricots adapted for colder climates. There is still opportunity for excellent work in this direction on the part of other plant developers.*

## Dried Apricots

*The fruit developer must consider many things in producing a new variety. In the case of the apricot, evenness of size and drying quality are essential. The boxes of dried apricots here shown illustrate the attractiveness of a fruit in a perfected variety of almost ideal quality.*

merely of the fruit but of the tree on which it grows.

For within the infinitesimal structure of the nucleus, by the most mystifying of all Nature's feats of jugglery, are lodged those hereditary factors or determiners that will ultimately transmit the traits of the ancestral tree to the tree of the future.

In the widest sense it is true that the sole purpose of the entire plant is to produce a certain number of these germinal nuclei, each representing the union of a pollen grain with an ovule; each carefully encased in the structure that we call a seed; and each capable of reproducing, with sundry modifications, the characteristics of the parent plant, or, in a profounder view, the blended characteristics of the entire ancestral race which the plant represents.

When we consider the seed in this way it does not seem strange that all the resources of Nature should concentrate on the development of the fruit structure in which the all-important seed or cluster of seeds finds lodgment. And by the same token it is comprehensible that Nature will hold to the seed with the most unwavering persistency.

And so it is not strange that the plant experimenter should be able to alter the size and texture and quality of the fruit pulp far more readily than

he can modify the core or stone that lies at its center.

Yet from man's standpoint this inevitable central structure, forming the heart of every orchard fruit, is a conspicuous detriment. And it is altogether desirable that fruits should be developed in which the stony or fibrous covering of the seed is eliminated, or in which the substance of the seed itself has been substituted by juicy tissues.

Everyone knows that this much desired modification has been effected, or all but effected, in the case of the so-called navel orange. An accidentally discovered mutant, doubtless a pathological specimen, was seized on by some keen-eyed observer, and a race of seedless oranges was developed by selection, and widely disseminated by grafting. Also there are seedless grapes.

The reader will recall the long series of experiments through which I was enabled, by taking advantage of a similar malformation in a wild European plum, to develop by hybridization and selective breeding a race of stoneless plums.

Everyone knows, also, that there comes to us from the tropics a familiar fruit, the banana, that is seedless; although perhaps it is not so well known that this fruit has lost its seed through being propagated for long generations by division. The precise steps through which this development

has taken place in the case of the banana are not matters of record. But its condition is similar to that of the sugar cane and of the familiar horse-radish in our gardens, both of which have been so long propagated by division that they have abandoned the habit of seed formation. The banana in its wild state was practically filled from end to end with large, hard, bullet-like seeds or stones, with just enough pulp surrounding them to make the fruit attractive to birds and wild animals that could not destroy the seeds. In this state it was practically worthless to man. Had not a pathological form appeared without seeds, which must be cultivated solely by division, the banana would be a practically useless fruit to-day.

And, for that matter, the potato furnishes us with an even more familiar illustration of the renunciation of the most primitive and important of all plant functions, that of seed bearing, which has developed under cultivation within the past half century.

But among orchard fruits of temperate zones the orange and the stoneless plum, as just instanced, are the only examples of plants that have been thus profoundly modified—although a seedless (but not coreless) apple and pear, in the experimental stage of development, have been announced. These examples, however, are stimu-

## *The Nectarine*

*The fruit here shown, the nectarine, is much less familiar than it deserves to be. It is in reality a form of peach. The botanists question whether it is not specifically identical with the ordinary cultivated peach. It will appear in the text that Mr. Burbank has made remarkable experiments in crossbreeding and hybridizing the nectarine with the peach and with the almond.*

## The Crabapple

*The figures at the left show the American crabapple, those at the right the Chinese crabapple. It is possible that the American fruit owes its relatively large size to attention paid it, in the way of cultivation, by the Indians at a remote period. In any event, this fruit has qualities that make it a desirable parent in hybridizing experiments. We shall see that Mr. Burbank has used it to good advantage in this way.*

lative. They show that the possibility of co-operating with Nature is almost limitless; and it is hardly to be doubted that the plant experimenter of the not distant future will carry out the process of making all our orchard fruits seedless and coreless.

As I said before, this is doubtless the most important opening that presents itself for the fruit developer. It is a field in which there is room for all and the allurements of which should prove inviting to a vast number of workers.

*—When you work with fruit trees you are making permanent records—reaching out your hands to future generations—erecting a monument that will remain long after you are gone.*

## *Making Over An Old Orchard*

*Countless farms and dooryards of the United States have orchard trees in larger or smaller number that are practically useless. These can be made over, by proper grafting, so that they bear the finest varieties of fruits. The picture illustrates the way of rehabilitating an old apple tree by grafting all of its larger limbs. The tree is thus entirely transformed, and may come to bear fruit of the most delicious quality.*

# Practical Orchard Plans and Methods

## How to Begin and Carry on the Work

"WHAT kind of tree is that, Mr. Burbank?"

Seldom does an amateur visit my experiment farms without asking this question. And very commonly I am led to reply:

"Why, it is hardly fair to speak of that as a tree; that is a concentrated prune orchard. If I were to name all the varieties of fruit that are growing on the branches from that single trunk, it would sound like reciting the names from an orchardist's catalog. Nearly all my important experiments in developing a particular variety of plum are made, at one stage or another, in these tree-colonies."

And when my visitor, observing now on closer inspection that practically every branch shows evidence of having been grafted, inquires what will be done next season, I explain that a fair proportion of the present branches will be cut away and

grafts from other seedlings put in their place for further tests.

The usefulness of a tree as the basis of further experiments is not finished by any means when it has once been covered by grafted cions. The same process may be practised over and over.

Doubtless no other observation made by the average amateur visitor is matter for greater surprise than this utilization of single trees for the carrying out of vast numbers of experiments. The utility of the method, in the saving of both land and the experimenter's time, is altogether obvious once attention is called to it. Yet relatively few, even among professional fruit growers, have hitherto gauged the possibilities of the method.

Of course the average visitor who inspects my gardens has no thought of becoming an experimenter on a large scale, and hence would not have occasion to practise multiple grafting and regrafting on any such scale as that employed at Santa Rosa and Sebastopol. But I call particular attention to this matter of fruit-tree grafting, because there is a lesson in it not merely for the professional fruit grower but for tens of thousands of persons scattered across the length and breadth of the country who have in their gardens a few fruit trees, at present of no apparent value, that might be made to bear in abundance.

*A Box of Seedlings*

*The first step, of course, in rehabilitating an orchard, if new varieties are sought, is the planting of seedlings and the proper care of them, which has already been described in a preceding volume. This picture shows sprinkling the box of seedlings with sulphur in order to prevent damping off.*

Moreover, there are other thousands who have on their farms neglected orchards, run riot with weeds and bringing no monetary return whatever, which might be made the most productive and valuable portions of the entire acreage.

And in each case the grafting of the cions of good varieties of fruit on the old and otherwise worthless stock is the key to the entire situation.

### Old Trees Made Young

We shall have occasion in the successive chapters of the present volume to examine in detail the methods of cultivation and possibilities of improvement of the different orchard fruits. Here it may be of service to take a brief general view of the subject. And at the outset I wish to emphasize the possibility of making over the orchard material which is now in hand, so to speak, and which is being so sadly neglected.

Reports from all over the country tell the same story. In Ohio, for example, according to the report of experts of the Agricultural Station, there are thousands of acres of idle orchards. The product of apples—the chief orchard fruit—has fallen to less than a fourth of what it was a generation ago. Apple trees themselves are about half as numerous as they were; and this implies that those that remain are only half as productive as the trees of twenty-five or thirty years ago.

Such a record, coupled with the fact of an ever-increasing demand for orchard fruits, seems almost incomprehensible. Yet similar reports might be had from numberless other regions where fruit production was formerly a more or less important industry.

But fortunately the facts of the situation are now being called to the attention of the general public, in particular by the workers at the agricultural experiment stations. Bulletins are being issued that call attention to the possibilities of rejuvenating the old orchards, and in many regions results of this work are being manifested in the restoration of abandoned orchards. In one county in Ohio, in a recent season, 117 rejuvenated orchards added more than fifty thousand bushels to the apple crop.

"In several cases," says the Ohio report, "a net profit of $400 per acre has been secured from an abandoned orchard."

The report continues: "It is like reaping where one did not sow, to bring one of these orchards into its own again. An investment in one of these orchards is better than gold mine stock, for there is no 'luck' about it. If there is any risk about operations of this sort, it is because of lack of business capacity and industry. To take a neglected orchard and bring it back to usefulness does not

require much capital except in brain and muscle, but it is an achievement worth while."

An achievement worth while, the renovation of an old orchard, or even the rejuvenation of a single tree, certainly is. I can gauge something of the growing recognition of this fact from the ever-increasing number of letters that come to me from all parts of the world asking my opinion or advice as to the possibility of restoration to usefulness of trees that their owners not long since regarded as worthless.

And I am usually able to assure the questioners with a good deal of confidence that if they go about it in the right way they will not merely restore trees to their former level of productivity, but may make them producers of fruit in such abundance and of such quality as quite to outclass their original record.

### Housecleaning in the Treetops

I need not here enter into details as to the exact methods of operation through which such restoration and rejuvenation of old orchard trees may be brought about. Such details can be given to better advantage in the chapters that deal with individual fruits. But there are a few general principles applicable to the entire class of fruit trees that may be briefly outlined.

First and foremost, perhaps, is the matter of

## A Row of Plum Seedlings

*It will be seen that some of these seedlings have outstripped the others in the matter of growth, and in luxuriance of foliage. Experience has shown that seedlings that thus start out well are likely to continue their relatively rapid growth and to make far better trees than the stunted ones beside them. A knowledge of the qualities of the seedling enables Mr. Burbank to select at an early stage the ones that are to be preserved, thus making experiments of an elaborate character, on a relatively small land area.*

cutting away the surplus growth of half dead twigs and branches that a neglected tree is sure to exhibit. These serve to distract the energies of the tree, if the phrase be permitted, and even though they may multiply the number of fruit buds, they will greatly minimize the average size of the fruit itself.

Regardless of quality, fruit trees generally cannot bear to advantage unless properly pruned.

The process may best be carried out late in the winter or very early in the spring. It is well, as a matter of course, to make clean, sharp amputations, so that the bark of the limb below the cut is never torn. No general rule can be given as to the amount of pruning for any species; much less for any individual tree. But it may be taken for granted that the amateur will usually err on the side of pruning too little rather than too much.

Where small twigs are cut away by the pruning knife, it is not necessary to treat the stump; but larger branches, requiring the use of the saw, should have the stump covered with hot wax or paint to protect the injured tissues from the weather during the period of healing. This should not be done immediately, but should be delayed for a week or more until evaporation has dried the tissues sufficiently to allow absorption of the protective material used.

In connection with this removal of supplementary branches, which is in effect a sort of housecleaning operation, it will be well to scrape off the rough bark of trunk and limb wherever it scales in such a way as to afford snug retreats for insects. And blemishes of a more important order, such as knotholes and decayed surfaces where limbs have been cut away or broken off in the past, should be carefully excavated, all unsound tissue removed, and the cavity filled with ordinary Portland cement or concrete.

The latter process has been variously characterized as tree carpentry and tree dentistry.

Both terms are more or less suggestive of the work achieved, regardless of names. The operation may result in prolonging indefinitely the life of a valuable tree that would otherwise soon have decayed beyond restoration.

The trunk and branches of the tree having been put in order, thought should be given to its root system. The casual observer is likely to forget that only about half the tree is visible, and that the aerial half is not fundamentally more important than the subterranean moiety. Yet it is obvious that the root system furnishes the all-important source of supply of moisture and mineral matter, lacking which growth could not take place at all, let alone fruit bearing.

Of course we cannot get at the branches of the roots to renovate them as we have renovated the aerial branches, nor would they require the same kind of attention if we could.

There is no danger that a plant will have too many rootlets, for these are the mouths that reach out into the nutrient earth and take up the chemicals in solution that are part of the materials for the building of branch and leaf and flower and fruit alike. But there is danger that the root system may not develop in the best manner, and there is obvious need that the soil into which the roots penetrate should not be depleted of its nourishing properties.

As to the manner of development of the root system, of course it is too late to make radical changes if we are dealing with an old tree. With young trees just starting growth or recently transplanted much may be done, as will be pointed out presently. But with the old tree all that can be accomplished is to see that the root already in is being given a fair chance.

### Attention to the Commissary Department

To this end the ground about the tree should be cultivated with plow or spade, even at the hazard of destroying a certain number of superficial rootlets. The grass and weeds that have been permitted to spring up in the neglected or-


## *A Bunch of Selected Seedlings*

***This picture shows a bunch of selected seedlings that have been carefully dug in the proving ground and are now ready for transportation and final disposition. It will be seen that care has been taken to dig up the entire root, without injury. Seedlings thus carefully transplanted will lose very little in the process, and are almost sure to continue growth if properly cultivated after transplantation.***

chard sap the ground and take the nourishment that the tree imperatively needs. But if the surface soil is turned under this vegetable matter will in itself constitute a fertilizer. Unless the soil is unusually rich this should be supplemented with artificial fertilizers, of which nitrates, phosphates and complete mineral fertilizers often appear to have the best effect in rejuvenating an old orchard.

In case the soil is a sandy loam, subject to rapid leaching, it may be desirable to sow a so-called "cover crop" to prevent the too rapid washing away of the plant foods in the rainy season. If a leguminous crop is grown, such as clover, crimson clover, cow peas, or vetch, these crops will in themselves add to the nitrogen of the soil, as their roots have the power of taking this from the air. But it is urged by some eastern orchardists that care should be taken to avoid too much nitrogen. The roots of the tree reach down to rich subterranean sources that are likely to be well supplied with nitrogen, because the nitrates are very soluble and are pretty rapidly leached or filtered into the subsoil.

After preliminary treatment it has been found in many states best to sow a crop of clover, often with other perennial grasses, as a permanent crop, which should be cut and all material left on the ground for the protection and support of the or-

chard. This has been found to be an extremely profitable method both in the old neglected and in the new orchards of New England and in the orchards of the northwestern Pacific coast. A small space about the trunk of the tree should be kept free from grass.

The experts of the Indiana Experiment Station recommend as a fertilizer, for soil of fair natural fertility and where a leguminous nitrogen-gathering cover crop such as just suggested may be grown, the additional use of a fertilizer having the following formula: "A thousand to fifteen hundred pounds per acre of a mixture containing one part (100 pounds) each of ground bone, acid phosphate and muriate of potash. On soils that are somewhat exhausted, 125 pounds nitrate of soda may be added in addition.

"In order to get the greatest returns from this fertilizer it should be thoroughly worked into the soil. This can be accomplished very well by applying it to the surface just before plowing. The plowing and working of the ground will get the fertilizer pretty thoroughly incorporated, and the tree will soon show the beneficial effect of its presence. Hoe the ground often and keep it cultivated until midsummer, then sow a cover crop that will protect the ground until it is turned under the following spring."

After these reformatory measures have been carried out, it remains to guard the trees against the attacks of insects with some protective spray.

The particular insect or fungus-destroying mixture required will of course depend upon the individual case. The Bordeaux mixture is doubtless used more than any other single spray for fungus diseases and for the codling moth in apples. A lime-salt-sulphur solution is the general mixture for San Jose scale. In general, it should be recalled that spraying is a preventive measure rather than a cure. Bordeaux mixture, for example, will prevent the appearance of the fungus disease commonly called scab. The attacks of the codling moth may be met in the same manner; but as there is a second crop of these moths, another spraying may be necessary later in the season.

### Battling the Pests

I should add that as to this matter of fighting plant diseases and pests with the spray, as also in the matter of the renovation of neglected orchards, I must offer advice rather at second hand. My own orchards, as a matter of course, have not been neglected. While my orchards are cultivated thoroughly, so that a weed is seldom seen, very little fertilizer is used and rarely any spraying, as my object is to obtain varieties that are immune to fungus and insect diseases, and which will

*Nursery Stock Awaiting Final Transplantation*

*Here bunches of seedlings such as those shown in the preceding illustration have been set out temporarily en masse to keep them in condition until time can be found for their individual transplantation. In cold weather and in dry soil the seedlings may thus be preserved almost indefinitely, retaining their vitality and being ready to take on growth when transplanted individually.*

thrive in ordinary soils and under ordinary systems of cultivation. No pampered pets are offered from my grounds for general culture.

I would urge any orchardist who operates on a large scale to consider the matter of selecting as far as possible varieties of fruit trees that are more or less immune to disease, rather than to depend on the at best somewhat precarious method of warding off the enemies by spraying. Prevention is better than cure with plants no less than with human beings. But of course the renovator of an old orchard, whose task is at the moment under consideration, must work with the materials supplied him and cannot ignore the fungus and insect pests that attack his trees; although by dint of proper grafting he may hope presently to transform the character of the trees in such a way as to give them partial immunity. The orchardist of the future will have still better ones in these regards.

### Planning a New Orchard

So much for the renovation of the old orchard. I have spoken thus at length on this aspect of the subject because of its obvious importance, and because it aims at the correction of a widespread condition and has to do with the possible restoration of properties in the aggregate of enormous value.

## The Choice of Seedlings

*To economize space, seedlings may be grown close together during the first few months, until the individuals have revealed their qualities. Then, of course, the weaklings will be weeded out and room given for the thrifty ones to continue growth. This picture illustrates the difference in growth—notably in sturdiness of stem—between two seedlings from the same lot of seeds. It is obvious that the orchardist will preserve the one at the left, as the much likelier fruit-producer.*

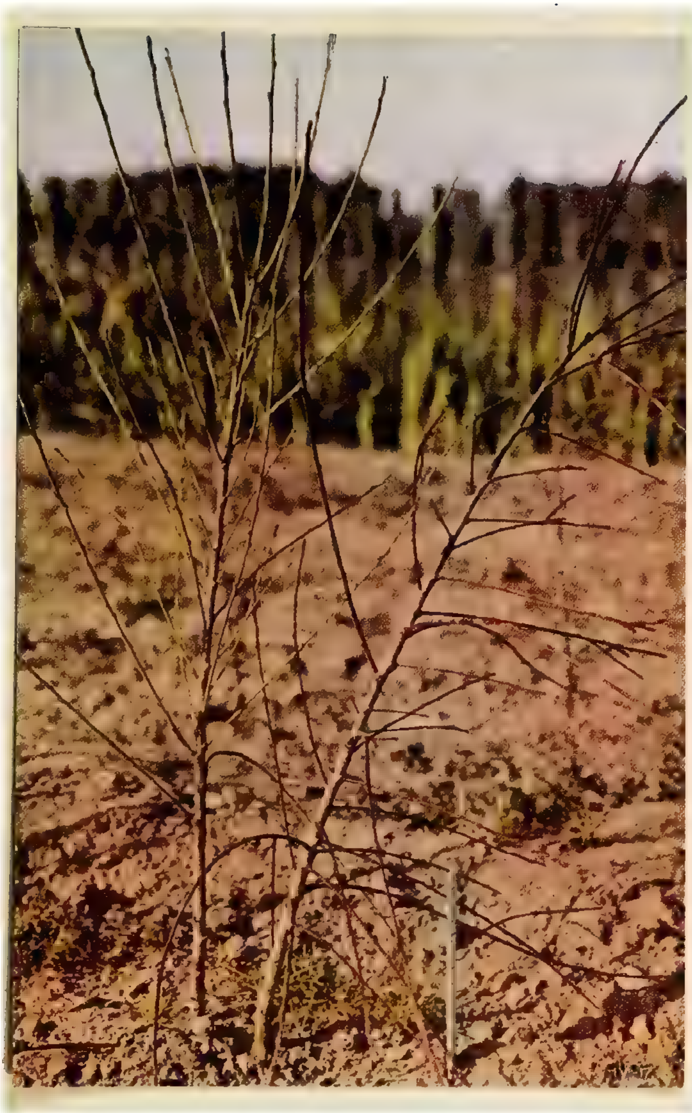
It takes time to grow a tree, and it is peculiarly fortunate that the would-be fruit grower can secure almost anywhere an abandoned orchard that may almost immediately be restored to a condition of productivity. But of course the orchardist who wishes to operate on an extensive scale will not be content with the renovation of an old orchard, however lucrative that process may prove, but will wish to produce a new orchard that may lack the defects of the old one.

The ancient tree made over will still retain, in such important matters as height and spread of limb, the evidence that it really belongs to a past generation, however insistently the fruit that its grafted branches bear may seem to belie the evidence.

But the trees of the new orchard may be trained in accordance with modern ideas; and it is not to be denied that ideas as to tree pedagogy have changed as rapidly in recent years as have the best conceptions of human pedagogy.

Take the very important matter of height of tree as a case in point. Not long ago the orchardist, in developing a young tree, was careful to see that it was trained in the nursery so that its lowest branches were several feet from the ground.

But the well-informed orchardist of today heads his tree in such a way that the bearing



## *Selecting Among Peach Seedlings*

*Here two peach seedlings are shown between which it may be somewhat difficult to decide. The one at the right is somewhat larger and sturdier, but that at the left is much better formed, its branches being upright, growing at the ideal angle of about forty-five degrees. The latter will therefore make better trees, but the one at the right has qualities of color of stem, and of sturdiness that may make its preservation desirable. Two quite different varieties of peach may be expected from these two seedlings of the same stock.*

branches start only eighteen inches or two feet from the ground.

Where formerly high ladders were required to pluck the fruit, a modern orchardist, for a good many years after his trees are in bearing, can stand on the ground and reach the main bulk of the fruit; and even that which falls is not mutilated and bruised as it used to be. Also the trees are much less apt to be broken or blown over by the wind.

And in this I am not referring to such "freak" trees as, for example, my little bush-like quinces, scarcely waist high yet almost breaking under the weight of mammoth fruits. I am speaking of the commercial orchard, and have in mind in particular the apple tree, because it is with regard to this tree that the most conspicuous transformation has been effected. Plum trees and peach trees were never very large, but it used to be taken for granted that the apple tree should be of gigantic proportions; so the half dwarf trees on which the best apples of today are grown might seem to the casual observer to belong to a different family of plants from their progenitors.

### Gauging Your Climate

As to other desirable qualities, much depends upon the location of the orchard and the market that the orchardist has in view.

It goes without saying that the varieties to be selected must be of a character adapted to the climate and soil of the chosen region. As to this, the restrictions imposed by Nature are more or less familiar to every fruit grower. In general, you may judge to a certain extent from observation of what is already grown in your neighborhood as to what kinds of trees will thrive there. The chief restrictions are those imposed by conditions of temperature, and of course temperature is influenced not merely by the latitude but by distance above the sea level and the neighborhood of large bodies of water.

The presence of moisture in the air has a protecting influence, chiefly in that it prevents radiation of heat at night. Every orchardist knows that the danger from frost increases in proportion as the night is clear. The now familiar method of fighting frost by burning brush or oil supplies direct heat, but also supplements this by filling the air with smoke, which retards the radiation of heat.

It is familiarly known that seaboard regions have much milder winters than inland regions of the same latitude.

Again, inland regions of low altitude, such as the Mississippi Valley, may be adapted to the growth of a fruit that would inevitably winter-

kill if grown on the high plateaus of Wyoming. In general, it may be said that no region at higher altitude than about six thousand feet is adapted for fruit growing.

In putting out catalogs of new fruit it is often desirable to state the minimum temperature that a new production will stand. I have done this, for example, in announcing my spineless cactus. As to average annual temperature, it may be convenient to recall that there is likely to be a mean annual difference of three degrees for each hundred miles of latitude. Thus, for example, the mean temperature at the southern line of Iowa will be found to be about three degrees lower than the mean temperature at the northern line; and this difference might, in case of a given fruit, make it folly to plant in northern Iowa a fruit that might live in the southern part of the state.

As already pointed out, however, one of the main objects of the plant developer today is to produce hardy varieties, and doubtless it will be possible in the future to grow most varieties of orchard fruits in regions that are now regarded as lying wholly beyond the northern limits of their possible culture.

### Studying Your Market

Of course the proximity of the market is an item of chief importance. Yet the experience of

## *Combining Young Orchard and Berry Field*

***This picture illustrates the possibility of economizing space and labor by planting vines of the blackberry or raspberry between the trees of a young apple orchard. The vines come into bearing and produce a lucrative crop during the years when the apple trees are making their early growth, and are as yet unproductive.***

the California plant developer may be cited as showing that nearness to market is by no means an absolute essential. For of course it is well known that the California fruits are now chiefly grown for shipment to the Atlantic seaboard. So nearness to a railroad is even more important, as hauling fruit for any great distance before it is packed for eastern shipment is a great detriment to its shipping and keeping qualities.

Except in a few cases, like that of the prune, it is always necessary for the California plant developer to consider the shipping quality of his fruit. A fruit to be shipped a long distance must be of firm flesh, a good color, and a reasonably tough skin. And especially it should be uniform in size and of such shape as to admit of economical packing. Moreover, it should ripen at a season when the same kind of fruit is not abundant in the distant market.

So it may happen that a fruit otherwise valuable may lack this essential marketing quality, and hence must be avoided. This is the reason why my Abundance plum is not so popular in California as it is in the Eastern States, as it will not stand a long shipment so well as other varieties. To the eastern fruit grower this is not important, as he lives near the market. But from the California standpoint, such plums as the Wickson, the

Burbank, the Formosa and the Climax, all of which are excellent shippers, are generally preferred.

The advantages of entering the market at a particular season are illustrated by the Burbank cherry, which ripens so early that it reaches the eastern markets when almost no other fruit is on hand. The fact that these cherries often bring two or three times the market price to be secured a few weeks later shows the practical importance of this detail.

Another seemingly minor point that the prospective orchardist should not overlook is the question of the color of the varieties of fruit he is to select. Color is one of the most important characteristics of the fruit from the market man's standpoint. The purchaser at the fruit stand will very generally pick out the highly-colored fruit without considering its quality. The prospective fruit raiser should bear this in mind in selecting his stock.

### The Orchard Site

In dealing with an old orchard the fruit grower must obviously take the trees as he finds them. But in developing a new orchard he should give very careful attention to the exact topographical conditions. The matter of drainage of the soil is important, and also the question of exposure to the sunlight and wind.

If your orchard site slopes toward the south, and does not lie in the shade of mountains nor where it is subject to the equalizing influence of a large body of water, the trees are likely to be so stimulated by the nearly perpendicular rays of the sun as to blossom before the time of the last frost. Early blossoming might at first thought be considered an advantage; but in point of fact it is a general rule that plants which blossom early ripen their fruit late, whereas those that blossom late are usually early ripeners. The obvious explanation is that the trees that flower late and ripen early have had to adapt themselves to short seasons.

The wisdom of their course is emphasized when we see the early blossoms of trees on a southern slope cut off by a late frost, while trees otherwise situated in the neighborhood have not yet come to blooming time.

The danger of entire loss from late frosts may be obviated, however, by the selection of varieties that will mature fruit even after the blossoms have been frozen. I have developed such varieties of fruit trees in a number of instances. There are also varieties that have a long blooming season, and these may be depended upon to put forth new blossoms even if the earlier ones were blasted. But in general it is desirable to select a variety of

## *Orchard and Vine Field*

*This picture shows a nearer view of the orchard shown in the preceding picture, the first view being taken when the apple trees were two years old. It will be seen that the apple trees are now attaining a fair growth, yet that there is still ample room for the berries. If the apple trees are of the modern type, and are kept well pruned, the combination of vine, field and orchard may be permanent, provided the apple trees are not planted too close together.*

tree that naturally blooms late enough to avoid these frosts.

This is especially important in view of what has just been said about frosts waylaying trees on a southern exposure, because precisely such exposure is of value at the other end of the season, to hasten the ripening of the fruit. This is not only important in the case of fruits designed to meet an early city market, but it applies to many varieties that tend to ripen late in the fall and which thus may suffer from the early frosts of autumn.

It should be recalled that the warm southern exposure also tends to take the moisture from the soil early in the season, so varieties planted in such a location should be able to resist drought.

Trees planted on a hillside will probably have natural drainage. Otherwise it may be necessary to drain the soil with tile or with open ditches, or else to select varieties of fruit that are known to thrive in a moist, cool soil. Such varieties must necessarily have an unusually large leaf surface and shallow root system. For this reason they should not be placed where they are subject to heavy winds.

What may be called air drainage is sometimes quite as important as water drainage. Cold air flows down the hillsides and settles in the valleys.

**A Typical, Regrafted, Rehabilitated Apple Orchard**

*The trees here shown were not originally of the best varieties, but by rigorous pruning and regrafting, they have been brought to approximately ideal shape, and made to bear fruit in profusion, of the finest quality.*

## Early-Bearing Peaches

*The peaches here shown illustrate the possibility of remodeling an old peach orchard by grafting. This bunch of luscious fruit was borne on a cion only two years old, grafted on a tree that otherwise would have borne fruit of inferior quality or no fruit at all. There are thousands of abandoned peach orchards that might be rejuvenated by proper grafting.*

So the bottom of a valley is a very poor place to plant fruit; except, indeed, in certain canyons or gulches where there is a steady current of air in motion throughout the night. In general, the orchard site should be on a hilltop or hillside, or at least at an elevation above the lowest land surface in the neighborhood, unless the valleys are either naturally or artificially well drained.

Without attempting further details in this place, enough has been said to show that there are almost numberless points to be considered by the up-to-date fruit grower in the development of a new orchard. What has been said will supply clues that the thoughtful orchardist may readily follow up. As to the specific fruits, further details, with particular reference to the practical aspects of the subject, will be given in succeeding chapters.

*—"In several cases," says the Ohio report, "a net profit of $400 per acre has been secured from an abandoned orchard."*

## *Mr. Burbank's* 400

*The picture gives a direct glimpse into the foliage of the large cherry tree at Sebastopol on which Mr. Burbank has grafted more than four hundred different varieties of cherries. Practically every branch here shown bears a different kind of cherry, and nearly all are of superlative quality. A single tree thus treated becomes in itself an orchard.*

# Doubling the Productiveness of the Cherry

## More and Better Cherries

WHEN I chance to see mention in the newspaper headings of the doings of New York's celebrated Four Hundred I am sometimes reminded of the Four Hundred of Sebastopol.

The particular Sebastopol that I have in mind is the place where my fruit farm is located, about seven miles from Santa Rosa. By the Four Hundred of Sebastopol I mean a very aristocratic colony, comprising four hundred families of pedigreed cherries, that are colonized on a single big tree in my cherry orchard.

I could speak only from vaguest hearsay as to the lineage of New York's aristocratic coterie, but may claim to discuss the pedigrees of the Four Hundred of Sebastopol with final authority. And I can vouch for the blueness of blood, so to speak, of every one of them.

That there are about four hundred families in my patrician cherry colony is a matter of accident, quite uninfluenced by any thought of imitation. It chances that year by year the process of elimination about balances the process of addition to the family, and the census of the colony is not greatly altered.

Reference has been made in various earlier chapters to the origin and development of the patrician cherries. They are closely related as to their remote ancestry, as I suppose is the case with the members of every other aristocracy. Yet, as we have seen, the ancestral traits are variously blended in the different families, and there is notable diversity among them as to individual traits. Some of them bear fruit that is vividly red in color, others fruit that is pallid; and there are corresponding divergences as to flavor, freedom of stone, sugar content, and all the rest of the complex characteristics of a well-bred cherry.

Of course these qualities are variously recombined in the progeny of each new generation. So I can never tell what surprise is in store for me when I raise seedlings from the fruit.

And there are always new additions to the colony that will only come into bearing next season or the season after and reveal what they hold in store.

*Some of the 400 Come to Judgment*

*This picture shows a few of the several hundred varieties of cherries plucked on the same day from the same tree, and laid out for Mr. Burbank's examination and selection. As new combinations are effected each season through cross-pollenization, there are always unique varieties to be found on the tree each June-time, and these new varieties, may, of course, be perpetuated by grafting.*

Thus it chanced that in the season of 1908 I found among the cherries one that bore quite the largest fruit I have ever seen; fruit, moreover, of the most inviting color and having qualities of flesh to match. Cions from this new stock will be sent out and will in due course colonize many an orchard with a new variety of fruit that is sure to find great favor.

But if I thus from time to time have pleasant surprises, I am also too often chagrined to find among my patrician cherries offspring that seem unworthy. But of course one hears of black sheep among the scions of even the noblest families, so it is not surprising that the blueblood cherries of Sebastopol offer no exception.

And as the black member of any human family is always held up as a warning example, I have thought that I might in the same way make the black sheep of my cherry colony serve a useful purpose by explaining somewhat in detail the reason for their appearance.

In so doing I shall be able, perhaps, to make a somewhat clearer exposition than has hitherto been attempted of certain aspects of heredity that are peculiarly important from the standpoint of the practical plant developer.

### Upper Case Qualities

We have learned something in earlier chapters

South American Cherries

*Much of Mr. Burbank's success has been due, as the reader is aware, to the hybridizing of plants brought from different geographical localities. This picture shows a South American cherry that has been used in the course of the crossbreeding and hybridizing experiments through which Mr. Burbank's many varieties of perfected cherries have been developed. It will be seen that the South American cherry differs quite widely in appearance as well as in the foliage from the ordinary cherry of the northern hemisphere.*

about unit characters and the way in which they are blended or mosaiced together to make up the personality of any individual plant.

It will be recalled that where the two parents of a given individual have opposing qualities as regards a given characteristic—where one, let us say, is black and the other white—it is quite the rule for one quality to dominate the other in such a way that the offspring precisely resembles, as regards that quality, the dominant parent—in this case the black one—and resembles the other parent seemingly not at all. And we have learned also that the latent or recessive character that is thus subordinated—in this case whiteness—will reappear in a certain proportion of the offspring of the succeeding generation.

Now, it has been found convenient by recent experimenters to adopt a graphic method that will make the printed accounts of their experiments more readily comprehensible. The expedient in question is the simple one of using a capital letter to designate the dominant factor of any pair of unit characters, and a corresponding lower case or small letter to designate the recessive factor.

Letting *"D,"* for example, stand for the dominant trait of blackness in the illustration just given, and *"d"* for the recessive trait of whiteness, we may concisely state the facts of inher-

## The Catalina Cherry

***This cherry grows in the Catalina Islands, Southern California. Its defect is the very large stone and the very small relative quantity of pulp. Probably, however, the fruit may be improved by selective breeding.***

itance as just noted in the following formula:

Parent "*D*" being mated with parent "*d*," the offspring, whether few or many, bear in each individual case in their germ plasm the factors "*D*" and "*d*" in combination. But if two of these offspring are interbred, there will be a splitting up of the factors and re-combination in such wise that in any average group of four of their progeny the result will be this: One member that is pure dominant (*DD*), two members that are mixed dominants (*Dd*), and one member that is pure recessive (*dd*). The *DD* individual is "homozygous" for dominant factors and will breed true to blackness. The *dd* individual is homozygous for the recessive factors and will breed true to whiteness. The two *Dd* individuals are heterozygous for the color factors, and whereas they are individually black their offspring will repeat the formala 1 *DD* + 2 *Dd* + 1 *dd;* they will reproduce, in other words, the conditions of the second filial generation itself as just analyzed.

Let me re-state all this, using only the letters, to show the convenience of the formula and at the same time to fix it in memory: *D* mated with *d* in the first generation gives us *Dd* + *Dd* + *Dd,* etc., in the second generation. *Dd* mated with *Dd* gives us in the third generation 1*DD* + 2*Dd* + 1*dd.*

## *Some Curious Short-Stemmed Hybrids*

*These black cherries, it will be observed, have the peculiarity of growing on exceedingly short stems. Such variations as this are observed in many hybrids, and of course they give opportunity for selection, through which permanent varieties are developed. Shortness of stem, however, in the case of the cherry is a merit that must not be carried too far, lest the cherries crowd each other too much in the bunches.*

If this is not absolutely clear, you will do well to re-read the above paragraphs, and it is quite worth your while to consider the matter somewhat attentively.

If you have only theoretical interest in plant breeding you should be concerned in the matter no less personally, because the same laws of heredity that are about to be illustrated apply with full force to all life, including human offspring.

If, on the other hand, you *have* thought of undertaking some experiments in plant developing, which I hope is the case, it is doubly important that you should get the full significance of these simple formulæ. Like other formulæ, they are devised solely for convenience in promulgating ideas. As used in the following illustration, they will make it possible to present vividly the case of our black-sheep cherry, and through this to clarify a large number of obscure cases that must prove very puzzling to the novitiate in plant development.

### Explaining the Black Sheep

Let us now stake our way, as it were, with the aid of the upper-case and lower-case letters, along the line of a series of plant experiments through which a certain patrician cherry was developed. To avoid complications and to escape getting into a tangle of ideas and a maze of letters, let us con-

sider only a single quality in detail, keeping in the background of our minds the idea that the actual experimenter is at all times considering almost innumerable other qualities as well.

The one quality that we will consider at the moment is, let us say, the matter of size. We wish, for some special purpose, to develop a cherry that shall be a giant among cherries, yet which of course shall combine size with quality.

Now we have at hand a cherry that bears very large fruit of poor quality. We have also at hand a tree that bears small fruit of delicious quality. Our first step will be to transfer pollen from the stamens of one of these to the pistils of the other. We carefully mark the limbs bearing the hybridized flowers; and subsequently we gather the fruit and save the seed and in due course plant it and nurture the seedlings by methods hitherto fully explained.

So when a year and a half has passed from the inauguration of our experiment we have a row of hybrid seedlings ready for grafting.

The one thought that is uppermost in our mind, for purposes of the present exposition, is that of securing a plant that will bear fruit of large size. Now we have learned that there are certain correlations of parts that will enable the plant experimenter to predict, from the quality of the

seedling, a good many things about the quality of the fruit it will subsequently bear. Utilizing this knowledge, we pass along the row of seedlings and select from among the thousand or five thousand individuals the ten or twelve that seem to us to give greatest promise. Nor at this particular stage of the development is the selection very difficult, for the first generation hybrids usually show no very great tendency to variation. That tendency is revealed in subsequent generations, as we have seen.

In point of fact, as a moment's reflection will tell us, the seedlings before us are really all of one quality as regards the particular characteristic of their innate tendency to bear large or small fruit. One of their parents bore large fruit; the other bore small fruit. If, then, we assume that here, as in many other cases of plant breeding, the quality of largeness is dominant to the quality of smallness, it may be expected that all the hybrids of the first generation will tend to bear large fruit.

If, introducing our convenient system of symbols, we designate the dominant quality of bigness with the letter *B*, and the recessive quality of smallness with *b*, we may designate the members of the hybrid generation as all being mixed dominants, each bearing the factors *Bb*. This means that the factor *B* dominates the factor *b*,

*Botan and Black Giants, Side by Side*

***The two types of cherries are shown here together, that their similarities and differences may be seen at a glance. The Black Giants represent one of the newest varieties developed by Mr. Burbank in his famous colony of four hundred.***

and that the individuals in question will all bear large fruit.

So we may expect (on this assumption), having grafted our selected seedlings, that each of them will show, two or three years hence, fruit of large size.

But of course the other qualities of this fruit will not be all that we could desire, so it will be necessary to continue the experiment.

Suppose we do this by cross-pollenizing different members of the same group. We shall thus mate *Bb* with *Bb*. And the result of this mating, as we know, will be to produce, in each group of four, one *BB* individual, two *Bb* individuals, and one *bb* individual. Being interpreted in terms of our actual row of seedlings, as they stand in our orchard in this, the fourth or fifth year of our experiment, this means that in every lot of four thousand seedlings one thousand are pure dominants as regards large fruit, two thousand are mixed dominants, and one thousand are pure recessives.

But now comes a very tangible and very practical complication. As regards their external traits, and as regards the fruit that they will individually bear, the one thousand pure dominants (*BB*) and the two thousand mixed dominants (*Bb*) are identical. There is nothing in their exterior

appearance, and there will be nothing in the appearance of their fruit, to indicate which of them contain only the factors of dominance (*BB*), and which contain the recessive factor combined with the other (*Bb*). Yet for the purpose of future experimentation, in which we shall be obliged to call on succeeding generations, it makes a vast difference which individuals are selected.

We are well aware of this as we walk along the row of our seedlings, but we are also aware that there is no method by which we can fathom the secrets of the germ plasm of our seedlings, to determine which are *BB* and which are *Bb* stock—save only the method of future breeding.

In spite of our best endeavors it may very well happen that the ten or twelve seedlings that we now select, to be grafted for the continuance of our experiment, include not a single pure dominant (*BB*), but are made up exclusively of mixed dominants (*Bb*). We have seen that the latter are twice as numerous as the others, and that the two look just alike; therefore the chances are two to one that they will be chosen in the majority, and it will not be strange if they are inadvertently chosen to the exclusion of the others.

Yet this choice will insure that the factor of smallness which we are striving to eliminate was carefully preserved in the germ plasm of the

cions of this second generation that we now graft into membership in the aristocratic cherry colony.

And when, after another interval of two years, these cions come into flower and are mutually cross-pollenized, the seeds they bear, being the offspring of mixed dominants ($Bb \times Bb$), will produce a generation of seedlings precisely repeating, as regards the quality under consideration, the formula of their parent generation. In a given lot of four thousand, let us say, one thousand will be *BB*, two thousand will be *Bb*, and one thousand will be *bb*.

And precisely the same difficulty in selection confronts the experimenter that confronted him before.

If he could only *know* which are the pure dominants and which the mixed one, all would be well.

But not only is it impossible for him to know this, but he may not be able even to determine with certainty, from examination of the foliage of the seedlings, which ones belong to the group of three thousand that bear the dominant factor (either *BB* or *Bb*), and which to the group of one thousand that bear only recessive factors (*bb*).

It must be borne in mind that the experimenter is really considering a large number of qualities, and it must be understood also that there may not be any clearly established point of correlation


*Mr. Burbank's Abundance Cherry*

*This is another of the comparatively recent developments in the famous cherry colony. It is often difficult to find names for the many new varieties that are developed at Sebastopol, but in the present case the word "Abundance" seems almost to suggest itself. It may be added that the cherries taste as delicious as they look.*

between the foliage or stem or buds of the seedling and the qualities of its future fruit as regards the matter of size.

So it may quite conceivably happen that the experimenter, using his best endeavors to make right selection, picks out for preservation, among the ten or twelve chosen out of the thousands, individuals that (though they have only large-fruited ancestors in the two generations back of them), yet themselves are pure recessives (*bb*) as regards that quality, bearing no factor of large fruit whatever.

And in that event the experimenter will be confronted, after another two-year or three-year interval of waiting, with an array of fruit, borne on the branches of his long-nurtured and carefully selected cions, not a single specimen of which is other than insignificant in size.

Other good qualities the fruit may have. But in the essential quality that we are keeping under consideration it is utterly lacking. In the matter of size it reverts to the recessive member of its great-grandparental ancestry. And so its telltale progeny, hanging there among the luscious fruits of surrounding branches (of other lineage), are like the black sheep in a patrician family.

Not an enheartening experiment, thus far, for the would-be developer of a colossal cherry.

*Branch of* 1909 *Cherries*

***The number 1909 here refers not to the actual number of cherries, but to the season in which they were first developed. They appeared that year on one of the branches of the famous tree, and they were at once seen to have such qualities as to merit further attention. The branch was therefore multiplied by grafting, and the new variety assured permanence. As yet, however, it has not been named.***

Yet the case is not really quite so bad as it seems. There is an old familiar saying that "blood will tell," and our new formula, if properly applied, gives full support to the saying.

Making application of it, we may say that the *dwarf* cherry which we have developed as the result of about nine or ten years' efforts at the production of a *giant*, is after all a thing of quality, even though it lacks one of the qualities that we are seeking. It is a scrub as to size, but it is none the less a thoroughbred as regards a number of other qualities. In the matter of color, let us say, it is a vivid red; it is sweet and appetizing; it is resistant to disease; it will bear shipping, and so on.

### Not so Bad as It Seems

Indeed, it is not unlikely that, as regards all desirable characteristics but one, our cherries are of such quality that, even in the patrician ranks in which they find themselves, they must be admitted to be "upper crust," to use a phrase that is said sometimes to pass current in human patrician circles. Or upon reverting to our formulæ, and therefore to the terminology of the printer, we may say that they are "upper case" as regards all qualities other than size.

As to bigness, to be sure, they are pure recessives and must be labeled *bb;* but as to juiciness

## *Other Nameless Seedlings*

*This picture shows some extra early seedlings that are now being given particular attention by Mr. Burbank. They have not as yet reached the stage of development when they will be named and sent forth into the world, but their present appearance gives assurance that this is only a matter of time. The reader is aware that Mr. Burbank develops hundreds of varieties of fruit that are in many ways valuable, but they do not meet his tests in all directions, and hence are never introduced.*

they are *JJ;* for shipping qualities they are *SS;* for resistance to disease *RR;* for hardiness *HH;* and for productivity *PP*. That is to say, they are pure dominants for each of these qualities.

Their germ plasm requires only an infusion of the dominant factor for bigness and their progeny will prove that breeding does tell.

There is a tradition that passes current among dog breeders which I do not vouch for but which suggests a condition so comparable to that of our cherry that I cite it by way of illustration. It is said that the greyhound had been bred so exclusively for speed that it developed all the desired speed qualities of a hunting dog, able to overtake any quarry, but lacked the courage to seize the quarry once it had been overhauled. To overcome this defect, so the story goes, some one crossed the greyhound with the bulldog, thus breeding in a strain of courage; and in subsequent generations eliminated all the bulldog traits except courage by selective breeding; and so gave us a race of greyhounds in which the one missing quality had been supplied.

This greyhound legend seems much more plausible to-day, now that attention has been so generally called to the segregation of unit characters, than it formerly seemed. But whatever its truth, the case of the hypothetical greyhound

strongly suggests the case of our black-sheep cherry. This also lacks but a single quality.

Can we not then breed this quality into our cherry and by remedying the one defect attain our ideal?

### Solving the Dilemma

Fortunately, yes. This is precisely what we can do, and what the wise plant experimenter will do.

We have but to look about in our cherry colony and we shall find another family, habiting perhaps a neighboring branch, the fruit of which exhibits in imposing measure the quality of size that our protege of the moment so notably lacks. This big cherry may even be the original dominant parent with which our experiment started. But it is a fruit which, although being everything that could be desired in size, is unfortunately quite lacking in color. In spite of its inviting bigness, it cannot make its way in the market because, even at full maturity, it has the appearance of unripeness.

But it *is* big, and bigness is the thing we are seeking. So we cross-fertilize the flowers of our little cherry with those of this big one.

The result is readily foretold. Bigness, as we have seen all along, is dominant, and so the offspring of this union are individually big. They

are mixed dominants (*Bb*), to be sure, but that, as we have seen, is something that concerns their descendants rather than themselves. Individually, they will bear big cherries, and that is all that we demand.

But what as to the color of our new fruit?

Here fortune again favors us. For it is very commonly observed that color of flower or fruit is likely to be dominant over lack of color. So our little red cherry, pure dominant as to color (*CC*) will stamp its influence in this regard on the progeny; the recessive color factor of the other parent (*cc*) being subordinated or made latent. In regard to color, as in regard to size, the progeny will be mixed dominants only (*Cc*).

But here again the fact that they have the recessive factor (*c*) is of no consequence, since as we have seen the mixed dominant tangibly presents the quality as markedly as if it were a pure dominant.

So when we have raised seedlings of this union of our little red cherry with the big white one, and when we have waited yet another pair of years, we shall finally be rewarded with the appearance on the cions, of fruit that meets our original ideal as to size, is as red as could be desired, and exhibits the other good qualities that entitle it to a permanent place in our patrician colony.

*Some That Have Proved Worthy*

***Here are cherries that have proved themselves of superior quality, yet which have not been named, and which perhaps will never be introduced. They have admirable flavor, but they lack something of the aboundant production that characterizes other of the cherries shown in earlier pictures. This fault will probably be remedied in their descendants, and these cherries will be represented in their progeny. The story of the combination of qualities of different parent forms to produce the ideal cherry is told in detail in the text.***

It has taken us about twelve years to accomplish this result. And even now our new fruit must be propagated by grafting and budding, for it cannot be depended upon to breed absolutely true from the seed.

The recessive factors for size and for color, as we have seen, are in its germ plasm; and these will make themselves manifest in the progeny.

But so long as we confine ourselves to the method of grafting, we may hold the type of the new variety and spread broadcast our big red cherry with its combination of desirable qualities, with full assurance that, given reasonable conditions as to soil and climate, it will reproduce forever the qualities of the patrician fruit, the ancestral history of which we have just traced.

### Inviting Opportunities

I have thought that by thus tracing in detail the history of a single experiment, paying heed chiefly to a single quality, but reminding the reader from time to time that other qualities cannot be ignored, we could perhaps gain a clearer notion than would otherwise be possible of the practical steps through which a new form of fruit is developed.

It is through such series of experiments, leading sometimes forward and sometimes backward in successive generations, that the four hundred

families of cherries of my patrician colony have been developed. No two among the four hundred show precisely the same combination of qualities, but all of them show one combination or another of good qualities.

Those that reverted to undesirable ancestral traits have been weeded out.

And this is equivalent to saying that the selected varieties of cherries represent a fixed stock as regards many of their good qualities. We cannot expect that any given one will reproduce its kind precisely from the seed, for reasons that have been fully explained. But we can expect that there will be a goodly proportion among any company of seedlings from this stock that would produce fruit of excellent quality. In a word, then, these perfected varieties of cherries represent stock that is immediately available for the purposes of further experimentation.

What they have accomplished is an augury of still better things that may be expected of their descendants.

And so the practical question arises as to what, specifically, are the qualities that the improved cherry still lacks; and as to what particular experiments in hybridizing should be undertaken to remedy the defects.

The first and perhaps the most important de-

fect that suggests itself is that the newly developed cherries, particularly the sweet ones, lack something of hardiness. They grow to perfection in California, but as yet they are little grown in the eastern United States, and not at all in regions north of Ohio and Missouri. Yet the race of cherries, taken as a whole, constitutes a very hardy stock. The wild cherries of the eastern United States grow far to the north and are able to withstand the winters even in regions where the mercury sometimes freezes.

It should be possible, and doubtless it will prove possible, to combine the best existing varieties of cherry with some of the wild cherries, and thus to develop a race of cherries that will retain the present qualities and introduce additional qualities of hardiness fitting them for growth anywhere in the United States; in fact this is a work in which I am now engaged.

The common choke cherry (*Prunus Virginiana*) is a very hardy tree, unusually productive, and almost indifferent as to soil and climatic conditions.

I have made experiments in the cultivation of this tree, raising thousands of seedlings from fruit of a large, handsome specimen that grew by the roadside near Westfield, Massachusetts. The experiments as far as conducted have been satisfac-

tory. Of course the fruit of this tree is astringent and almost as bitter as a green persimmon. But the little beach plum from which one of my finest plums was developed, was scarcely of better quality.

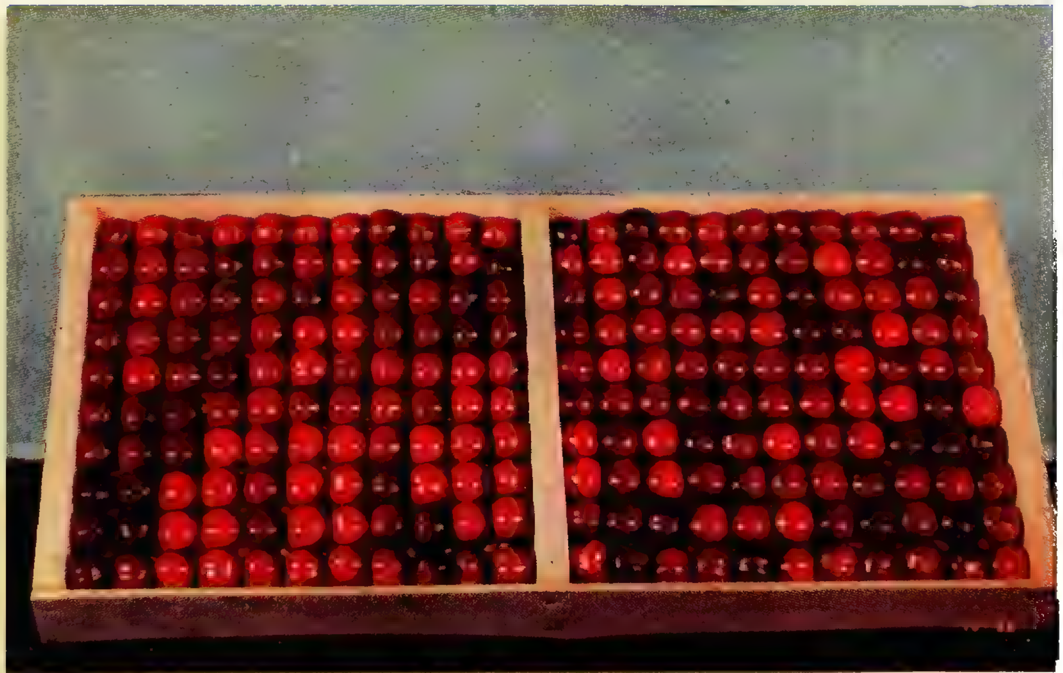
Perhaps it is not unreasonable to hope that it may be possible to make some such improvement in the cherry, through combination with the choke cherry, as I produced by hybridizing the beach plum with the Japanese plum.

In that event, we shall in all probability have a cherry surpassing any existing one in size (because of the virility that the cross with the wild species has given it), retaining the good qualities of the present Burbank cherries, and in addition being so hardy that it would thrive in any soil and in almost any climate.

If the choke cherry should fail to prove a satisfactory parent, there are numerous other wild species from which to choose. The black cherry of the eastern United States (*Prunus serotina*), is a tree that grows from Nova Scotia to Florida and westward to Dakota and Texas. It is of large size, and bears a fruit resembling that of a choke cherry in color and appearance, but of less astringent flavor. Then there is a small red cherry, commonly called the bird cherry (*Prunus Pennsylvanica*), the fruit of which is sour and astrin-

*A Box of*
*Burbank Cherries*

*The particular cherries here shown have been shipped twice across the continent before this photograph was taken. Note, in addition to the large size of the Burbank cherry, the uniformity of size, and the almost cubical form, making it an ideal cherry for packing. The particular cherry here shown is one that bears the name of Burbank. It was one of the first cherries introduced by Mr. Burbank, and is still one of the best.*



gent, but which is not without qualities of virility and hardiness that might make it a valuable hybridizing agent.

This is perhaps the hardiest of all cherries. I have seen it growing wild nearly as far north as Hudson Bay, in regions where it is not uncommon for the mercury to fall sixty degrees below zero.

The California holly-leaf cherry and the Catalina cherry are species that may be available for the development of other desirable qualities—for it is not in hardiness alone that the best varieties sometimes are found wanting; though the species just named are so far separated biologically and physiologically that it may be impossible to combine them.

Many cultivated cherries, for example, are unable to withstand the warm spring rains without serious loss from cracking of the fruit. Sometimes almost an entire crop will thus be ruined. Again many cherries are susceptible to blight. A bulletin issued by the State Commission of Horticulture of California lists more than twenty insects—leaf hoppers, scales, mites, caterpillars, and borers—that prey more or less upon root or bark or leaf of the cherry tree, or that attack its fruit.

Then there are inherent maladies, such as the tendency to overflow and condensation of sap, forming an injurious gum that may induce decay

of bark and wood (called gummosis), to which the cherry is peculiarly liable.

Hybridizing with wild species, intelligently and systematically carried out, might produce varieties of cherry that would show exceptional resistance to insect pests as well as inherent vitality that makes for healthiness in the tree.

It has long been my belief that a solution of the problem of protecting our fruit trees from both insect and fungus pests must eventually be found in the development of the qualities that make for immunity of the trees themselves, rather than in the resort to such expedients as spraying and "gasing." In this regard the plant experimenter may well take a leaf from the notebook of the physician, who has learned that immunity to disease often depends more upon the condition of the patient than upon the presence or absence of disease germs.

It is possible, furthermore, that the cherry may be hybridized even more widely, and that a fruit differing markedly from any cherry hitherto produced may thus be developed. An inkling of the possibilities in this direction is given by some experiments made recently by Professor N. E. Hansen, of the South Dakota Experiment Station, who has cultivated a variety of wild fruit, called the Sand Cherry, *Prunus Besseyi*, which is a dwarfed,

compact grower, of heavy form and good foliage, and which had previously been put upon the market as the Improved Dwarf Rocky Mountain Cherry. This native tree has a fruit nearly as large as the Richmond cherry and sometimes of fairly good flavor. The *Prunus Besseyi* has always been considered a cherry by horticultural and botanical writers. My experiments, however, seem quite clearly to demonstrate that it is more truly a plum.

I have had the tree under cultivation for more than sixteen years. The fruits of the original plant were black and bitter, almost as astringent as a persimmon. By combining this plant with various other American and Japanese plums, I produced abundant seedlings, and in 1904 had developed one especially promising variety. The fruit of this hybrid seedling ripens in California about August 10th, and is extremely large for this type. It is globular, and about one inch and a quarter in diameter. The color is pure, deep crimson, with a semi-transparent amber flesh, firm, juicy, and of a rich, sweet flavor, resembling that of the American plum. The tree is intensely productive, even breaking with its own weight of fruit.

It has been suggested that this tree gives great promise as an aid in the production of a hardy

type of fruit that will withstand the rigorous climate and conditions of the cold northern plains of Nebraska, Minnesota, and the Dakotas. What has just been said suggests that the fruit is not truly a cherry, yet the botanists seem to feel that it occupies an intermediate station, and is more closely related to the cherry than any other fruit.

Such being the case, it should be possible to hybridize this dwarf hardy species with the cherry. The tree has the further valuable property of being able to grow on dry, barren sands. A hybrid cherry having this characteristic from one of its ancestors might be expected to constitute a fruit that would grow in regions too arid for the existing cherry as well as in regions that are too cold. And this is but one of several lines of possible development that invite the plant experimenter who will give attention to this type of cherry.

To suggest one other line of improvement, it is sufficient to call attention to the familiar fact that the cherry has a very brief season. The Burbank cherry fruits two or three weeks earlier than others, as we have learned in another chapter. But even so the total period during which cherries of different varieties are in fruit is very limited. One hears reports of an exceptional cherry tree that fruits a second time in the au-

## *A Large, Late-Bearing Red Seedling*

***The cherry here shown, developed like the others previously shown, in Mr. Burbank's celebrated colony, differs from the one specifically called the Burbank, in that it is a very late bearer. The Burbank bears particularly early. It is desirable to extend the cherry season, and this variety has been preserved chiefly because of its lateness, although it has many other desirable qualities, as the picture suggests.***

tumn. By the usual process of raising numerous seedlings, or by crossing and selection, a variety having this fall-bearing habit might be produced. The value of such a variety is obvious,—though the early ripening of the cherry is at present what gives it greatest value,—and it is well worth the while of the amateur to attempt experiments in this direction.

The fact that cherry trees of one kind or another grow throughout the United States makes it possible for almost anyone to experiment with this fruit. And the opportunities for improvement are especially inviting.

*—In cherry trees, as in the human plant, "blood will tell."*

# The Responsiveness of the Pear

## What Has Been Done Is But The Beginning

A CORRESPONDENT who is seemingly prone to personify inanimate objects writes to ask which tree among our cultivated ones I regard as the most "human."

And then, without awaiting reply, my correspondent supplies the answer:

"The pear, of course," he says with full assurance.

But when he goes on to state the reasons for this decision, I am not quite sure that his argument carries conviction.

Perhaps the most striking bit of analogy that he offers is the fact that a pear tree sometimes fails to reach maturity until it is from fifteen to twenty years old, coupled with the cognate fact that the tree may continue to thrive for three score years and ten or even longer.

He cites a good many other analogies, or sup-

posed analogies, to be sure,—the fact that the pear over-rides adversity, as it were, bearing abundantly in bad soils and when totally neglected; the fact that it grows by roadsides and in dooryards showing a domestic habit and as it were a friendly spirit toward man; and finally, the fact that it responds to attention and proves as receptive and responsive to good treatment as it is resistant to bad.

But I am by no means sure that as to most of these traits, and for that matter in regard to any others that might be mentioned, the apple tree is not to be given a place quite on a par with that which the pear can claim. There is no occasion to dispute about the matter, however, for at best such comparisons have no great significance.

Let it suffice that the pear and the apple, close cousins as they are, may very well be considered the two orchard trees that are friendliest to man, in the broad use of the word.

They have been his associates probably almost from the earliest times when he learned that plants would respond to cultivation.

They have gone with him on his chief migrations throughout the temperate zone and even well into sub-arctic regions.

They have proved themselves adaptable to all soils and nearly all climates; and they jointly pro-


## *Seedling Pears*

***The pear is a fruit that has been very long under cultivation, and it has developed certain familiar and very individual characteristics. A comparatively few types have become popular and are raised everywhere. But nothing more is necessary than to plant the seeds, to secure seedlings showing the greatest variety as to their fruit. Two aberrant types are here shown, and numerous others are shown in succeeding pictures.***

duce a variety of pulpy fruits that stand in a class by themselves and are quite without competitors—or were until the quince came under the hand of the plant developer in very recent times.

### Early Migrations

Which of the twain, pear or apple, was first adopted, no one can say, but it is certain that both were friendly with man even in prehistoric times.

There is evidence from the ruins of remote civilization of the Lake Dwellers of Switzerland that the pear was known even in that day. Of course it was familiar to the Greeks and Romans from the earliest recorded periods of history.

Long before that it had come out of its central Asian home—if, as is almost certain, that was its original habitat—and had become thoroughly domesticated about the Mediterranean. Other branches of the same race had migrated eastward until they found a home in China and Japan.

And in these widely separated regions, at the extremes of the largest continent, the two descendants of the primitive stock developed, each in its own way, in response to soil, climate, and the diverse temperaments of the peoples, until the pear of Europe was in many ways a different fruit from the pear of the Far East.

But there was one migration made by prehistoric man in which the pear, apparently, did not

*The Long and the Short of It*

***No one unfamiliar with practical horticulture would suspect that these two pears were grown from seeds of the same fruit. They illustrate the strangely varied hereditary factors that find lodgment in the germ cells of a cultivated fruit. And of course they furnish material for selective breeding through which new varieties may be developed.***

accompany him. This was the final stage of the eastward journey of our remote ancestors which carried them across a land bridge, now no longer in existence, between northeastern Asia and the present Alaska, and thus brought them to America.

It seems a fair presumption that when prehistoric man made this final migration he brought the apple with him.

At all events, with or without man's aid, the apple made its way across the bridge that joined the continents.

Probably the fact that the seeds of the pear will not germinate when once dried may explain the failure of that tree to come with the forerunners of the Indian to the new continent.

The seeds of all orchard fruits germinate far better if they have not been too thoroughly dried. But the seed of the pear is peculiarly susceptible to destruction through drying; and if the ancestral pear had the same quality, which we need not doubt, this fact may in itself have been instrumental in restricting the spread of a tree which, when introduced in America in modern times, proved thoroughly adapted to our soil and climate.

We must not press this point too far, however, for the plum seed also dies if dried; yet the plum came to America in prehistoric times along with

the apple. And, for that matter, we shall see elsewhere that there is another possible interpretation of the story of the prehistoric migrations of the trees.

Be all that as it may, the pear retains to this day evidence of the inherent need, in the interest of its race, that the seeds borne at the heart of its fruit shall be preserved in a moist condition.

The skin of the pear, except in the most recently modified varieties, is firm and thick. It is of a green or mottled yellow color calculated to protect it from the observant eyes of birds and animals rather than to attract them. It has been assumed that the eatable pulp that surrounds the seed was designed by nature—that is to say, developed through natural selection—for the purpose of attracting animals and birds, that these creatures may aid in disseminating the seed.

But the case of the pear, in common with that of the wild crab apple, suggests that the chief purpose of the fruit-pulp is to keep the seeds moist through the winter. As a further aid to this, and in token of the moisture-loving quality of its seeds, the skin of the pear is fortified by a deposit of woody cells at its inner surface that give it a granular or even gritty texture.

This unique quality of the fruit may even extend to the pulp itself, especially with the more

primeval forms, giving the pear a texture different from that of any other fruit.

This unusual habit of depositing wood cells in the fruits, aside from the seed case itself, is no longer of use to the cultivated pear; but the fact that it tends to be retained shows how important a part it bore in the struggle for existence of the pear's remote ancestors.

But let us put aside theories as to the remote history of the pear and consider the fruit in its modern relations.

The significant thing to bear in mind is that in our day the pear is represented by two races, obviously related, yet quite as obviously long separated, one of them finding its home in Europe and (since the Discovery) in America and the other being indigenous to eastern Asia, the two having thus migrated in opposite directions, circling the earth, and finally meeting on the Pacific Coast of America.

And the fact that these two races of pears have thus diverged, yet still retain the capacity to hybridize, is an all-important one from the standpoint of the fruit developer.

This fact is, indeed, the basis of the newest progress in the development of the pear, and it gives the augury of still more important developments probably to take place in the near future.

*Broad and Sturdy Types*

*These are seedling pears of another type, although originated from the same source. They have qualities that make them worthy of preservation for further breeding experiments, but on the whole they have not been thought worthy of introduction.*

It is only fair to recall, however, that the new beginnings in the development of the pear took place in western Europe independently of an oriental alliance.

### New Beginnings in Europe

The pears of to-day, as known in the eastern United States, and for that matter most of the finest Californian varieties, are the bearers of an impulse to development that was given by a French horticulturist, Jean Baptiste Van Mons, and Andrew Knight of England about a century ago. Van Mons acted on a theory, now abandoned, that young plants produce the best progeny. But this led him "to sow, to re-sow, to sow again, to sow perpetually." And he selected his seeds with such care as to develop many improved varieties. In particular, he taught some pears to bear fruit in three years from the seed.

Van Mons produced by selection about four hundred new varieties of pears, among others a dwarf variety that was a prolific bearer.

Meantime, however, the pear was making its way in America, and one of the most famous varieties, the Seckel, originated in the early part of the nineteenth century on the farm of a man whose name it bears near Philadelphia. This was a "spontaneous" variant or mutant, the precise origin of which is unknown.

## Introducing Color

*Here are pear seedlings that not only show wide diversity of form, but almost equally wide variation in color. It has previously been pointed out that the pear usually lacks color. Here, obviously, particularly in the specimen shown in the center, is opportunity for the development of pears having richly colored skins like those of the apple. Mr. Burbank's experiments in this direction have already had interesting results.*

At the time of its origin the Seckel was pronounced by the conservative London Horticulturist Society to be superior to any European variety of fall pear then known.

Rather curiously it chanced that the next very notable step in the progress of the pear also took place on a farm near Philadelphia. The owner of the farm was Mr. Peter Kieffer. The thing for which he was responsible was the introduction of a pear bearing his name, which originated through the chance hybridization of a pear of European strain with the Chinese sand pear, which had been introduced as an ornamental garden tree not long after relations were established between America and the Far East.

The oriental pear which thus at last came to mingle its racial strains with those of this remote relative, after the two had traveled around the world in opposite directions, was a graceful tree having large and attractive flowers and bearing fruit of a pleasing fragrance but of such consistency as to be almost uneatable except when cooked. In spite of the defects of its fruit, however, the oriental pear had certain qualities of hardiness and resistance to disease that made it a valuable mate for its European cousin. So the Kieffer pair soon gained popularity.

So also did a number of other hybrid pears of

## *Diversified Colors*

*Although of the same heritage, no two of these pears show characteristics suggesting close relationship. Of the four, the one at the right is in some respects the most interesting, owing to its curious segregation of the different color pigments. The progeny of the seeds of this pear may be expected to show green individuals and red individuals, as well as those of various degrees of mottling.*

similar origin, including the Le Conte, the Garber, and the Smith. These hybrids soon became standard pears in the Gulf States, where the European pears do not thrive.

### Mammoth Pears in California

The hybrid pears did not gain popularity in California, because the climate and soil of this state seemed to be peculiarly hospitable to the European pears, notably the Bartlett.

By crossbreeding and selection these have been so developed, without hybridization with the oriental species, as to assume almost colossal proportions, and while differing widely in flavor from the original stock, to retain enough characteristics of the original to constitute a most valuable market fruit.

The California pears, indeed, have quite outdone themselves. They have been described as "grand in size, delicate in color and aroma, and of unsurpassed richness." A specimen has been reported that was "nine inches high, sixteen inches around the base, and five pounds in weight."

Pears of allied varieties show scarcely less notable tendency to grow to unprecedented size; for example, five Vicar of Winkfields are reported as weighing four pounds, eight ounces; nine Easter Beurre as weighing 24½ pounds, the heaviest single specimen weighing 2¾ pounds, and the like.

In the mere matter of size, then, there remains little to be desired; but there are other qualities as to which not so much can be said. In particular the pear is often susceptible to disease, and in general the extreme development of productivity has been more or less associated with a tendency to lose vigor, rapidity of growth and general vitality.

For this and sundry other reasons it seemed to me that it might be desirable to make further experiments in the blending of the oriental and occidental heredities. So as early as 1884 I made importations of the seeds of the Japanese pear. In a shipment containing loquats, plums, chestnuts, persimmons, gooseberries, blackberries, peaches and raspberries, I received also twenty pounds of pear seeds.

The seedlings were grown, but at first little use was made of them except as grafting stocks.

The valuable developments that ultimately came from the introduction of the oriental heredities were not secured at the outset.

### Traits of the Oriental Pear

About 1890 I imported from Japan large quantities of the seeds of the Chinese sand pear. The seedlings proved extremely variable. Some of them grew six or seven feet the first year, while others from the same lot of seed, under exactly

the same conditions, grew only a few inches; and a corresponding rate of growth characterizes the seedlings as long as they live. But, although the seedlings themselves proved so variable, their fruit was singularly uniform in size and quality.

As to shape, the fruit of the oriental pear is usually oblate, approaching the globular. This raises a rather curious, if not very important, question as to whether the European pear owes its very characteristic shape to artificial selection. The ordinary pear, as everyone knows, has a form that is so individual and so little duplicated, that no single word of familiar usage describes it. In this regard, as in a good many others, the pear is unique.

One would not commonly think of describing anything as "apple-shaped," or "peach-shaped," or "plum-shaped," but "pear-shaped" is a cognomen that is at once convenient and definitive.

So, as I said, the fact that the oriental pear has not assumed this shape has a certain interest and suggestiveness.

The hybridizing experiments that were begun as soon as I was in possession of the oriental seedlings called for more patience, perhaps, than almost any other tests that the fruit experimenter can make, for the very obvious reason that the pear is the slowest to mature of all the fruits grown

## *A Patrician*

*This seedling pear has qualities of form that entitle it to a special consideration. It has also good qualities of flesh, but, as will be seen, it is quite lacking in richness of color, except just about the stem, where there is a splash of red that suggests submerged hereditary color factors that might be brought to the surface by selective breeding.*

in temperate climates. It often requires from ten to twenty years for seedlings of the pear to come to their first fruiting. The matter may be forced a little by grafting the pear cions on quince stock, but while this makes them fruit earlier, it also tends to dwarf them, and I do not recommend this as a general practice, though highly desirable for special purposes.

Whoever has not patience to wait had best not undertake experiments with the pear.

With a tree of such slow development, it is peculiarly desirable to make no mistakes in selecting seedlings for preservation. Judgment as to the future tree must be based, as with other fruit, largely on its growth, and the appearance of the foliage. Pear seedlings that have an abundance of large leaves, and strong, thick, short-jointed wood, and thick, fat buds, are those to be selected. But this is not by any means as sure an indication of superior fruit in the pear as in most of our cultivated fruit, for the reason that Van Mons and other workers in this line have mostly sought early-bearing and fine quality of fruit, neglecting the foliage and growth of the tree almost fully.

### The Effect of New Blood

I grew great quantities of pear seedlings from seed imported in 1884 from Japan. The selected seedlings of this original stock have enormous,

glossy leaves, some of which for weeks after the first frost show varied and brilliant colors almost like the autumn foliage of oaks and maples of the Northeast. Many of the best of these were distributed for planting as ornamental trees.

Very early in the experiments I found among many seedlings of a cross between the Bartlett and the hybrid Le Conte one that seemed to have exceptional qualities. This proved to be astonishingly productive of fruit of the largest size and best quality, and the tree had extraordinary vigor of growth and was apparently immune to the blight.

But only one was selected as showing good promise as a fruit bearer. Through further hybridization and selection, during a period of nearly a quarter of a century, the hybrid progeny of this Japanese pear developed a variety that was introduced in 1911 as the "Test."

Year after year it had produced two or three times as much as any other pear that I had ever grown. The fruit averages rather larger than that of the Bartlett, and it appears about four weeks later. The flesh is similar to that of the Le Conte but superior to it in quality, although hardly comparable to that of the Bartlett except when cooked.

Although I have raised and fruited number-

less seedlings from a great variety of crosses, and have noted many variations, the Test is the only one that I have thus far thought worthy of introduction. Several hundred three-year-old seedlings of this new pear, grafted on quince stocks, give great promise by their vigorous, compact growth, heavy foliage and full, round buds.

Among those that have fruited are some mammoth pears of exquisite quality when cooked; and a few are good when fresh.

There is unusual variation in growth of wood, foliage, season of ripening, form, size, and quality of fruit. Some of the hybrids have a smooth, polished skin with red cheeks; others are russet throughout. The varying qualities of the hybrids are doubtless due to the releasing of latent characters brought about by the commingling of the two widely diverse strains.

It was necessary thus to hybridize and select through successive generations, because the oriental pear brought to the combination very undesirable qualities of fruit as to texture and flavor. Only when these were eliminated from later generations, and the qualities of the Bartlett and its allies substituted, did the hybrid pear become a commercial possibility.

But, along with its undesirable qualities of fruit, the oriental pear brought other qualities

*Unhandsome but Luscious*

*This seedling pear shows a tendency to depart from the typical pear shape, being much broader at the base, and correspondingly less graceful, than the favorite varieties. It has, however, qualities of flesh that commend it, but these were not considered by Mr. Burbank to be sufficiently exceptional to warrant the introduction of the fruit.*

that were pre-eminently desirable. First and foremost it had fundamental vigor of constitution that promised to supply precisely what the European pear most lacked. This was manifested not only in the vigor of its growth, but in its seemingly almost entire immunity to the attacks of the disease that has been the scourge of the pear growers of America for more than a century, and which made its appearance in California about ten years ago, the disease known as the pear blight.

### The Pear Tree Scourge

To appreciate the importance of this element of resistance to disease, as manifested by the oriental pear, it must be understood that the blight is a malady of such virulent nature that when it attacks the pear tree it very commonly results in killing it outright. This suggests, obviously, a peculiar susceptibility on the part of the pear. Such susceptibility is manifested, unfortunately, in exceptional measure by the best European varieties, including the Flemish Beauty and the Bartlett. This, presumably, is the penalty of over-specialization in a certain direction, or unbalanced selection.

Until very recently the cause of pear blight was much disputed, but the agricultural experiment stations have now furnished conclusive proof that it is a bacterial disease, due to the presence of a germ that has been named *Bacillus amolovorus.*

## ON THE PEAR

This germ has close cousinship with the various tribes of bacilli that cause the contagious human maladies. And there is a curious resemblance between the assault of the microbes on the pear tree and the corresponding assaults of certain bacilli, for example the diphtheria bacillus, on the human organism. In one case as in the other, the bacilli, once they find a lodging place, multiply inordinately and give out excretions that are virulently poisonous. Located on the flowers and fruit of the pear, or finding their way to the inner bark or cambium layer of the tree, they multiply prodigiously and exert a malignant influence that withers blossoms, blights the fruit, and causes the leaves to take on a bronzed red hue that is often premonitory of the death of the tree.

If they find lodgment in the cambium layer of the trunk, they may spread rapidly in every direction, until they girdle the tree, shutting off its supply of sap as effectively as if it had been girdled with an axe.

Wherever lodged, the colonies of bacilli may be located by the oozing out of a milky or dirty brown sticky liquid when the spring rains come. This liquid is attractive to insects, and as the feet and bodies of these marauders become covered with the germ-laden fluid, the transfer of the

germs to other trees and to flowers and fruit even fairly remote is thus assured. Not merely flies and gnats, but the bee itself may have a share in thus transporting the contagion from one tree to another till it infects every tree in the orchard.

The nectary of a pear, which the bee may inadvertently inoculate, furnishes a most favorable medium for the multiplication of the bacilli. Thence they work their way from the fruit buds to the limbs. Once they gain access, through the links in the tree's armor furnished by the buds, to the cambium layer of the inner bark, there is nothing to prevent the indefinite extension of their colony.

A tree thus inoculated may soon take on the appearance of a tree scourged by fire. Indeed, the malady is sometimes spoken of as "fire blight."

### Antiseptic Surgery in the Orchard

The measures taken by the horticulturist to save his tree when thus attacked are curiously suggestive of the methods of the modern surgeon. Infected limbs must be amputated; local areas of infection in the bark or trunk or large branches must be thoroughly excised, including a goodly portion of healthy wood and bark to make sure of the removal of every microbe. Large wounds are then carefully disinfected with a sponge or bunch of waste soaked in kerosene or in a solu-

## Dissimilar Twins

*These seedling pears are full sisters, notwithstanding their extreme dissimilarity of appearance. They illustrate the curious segregation of characters — in this case the color of the skin—in organisms of mixed heritage. It is obvious that the pear at the right has qualities of color that the plant developer is sure to seize upon.*

tion of corrosive sublimate, one part to the thousand.

It is merely antiseptic surgery applied to the tree to combat a microbe closely similar to the ones that are man's most malignant enemies.

But, of course, such measures as these, however necessary, can by no means be regarded as solving the problem of the pear blight. Just as the surgeon of to-day attempts to prevent the intrusion of the germs, rather than to depend on killing them after they appear, so the orchardist must hope to find a means of preventing the blight instead of being obliged to practice such heroic and wasteful curative measures.

One measure looking to this end that has been suggested is the destruction of old hawthorne and wild crab apple trees and of abandoned pear and apple trees in the neighborhood of the orchard, since a single infected tree would prove a source of danger to every tree within a radius of a mile or more.

Such measures are important; but they do not go to the root of the matter.

The real solution must come through making the tree immune to the attacks of the germ. This is the keynote of preventive medicine with the human subject to-day, as illustrated by the vaccine treatment, of which the most familiar example is


## *More Misfits*

***This picture shows seedlings of the same heritage that illustrate the extremes of form, somewhat as the preceding picture illustrated extremes of color. The figure at the right shows the ideal pear shape, upon which tradition has set its seal of approval. Mr. Burbank feels that the ideal pear should retain this shape, in deference to the taste of the public.***

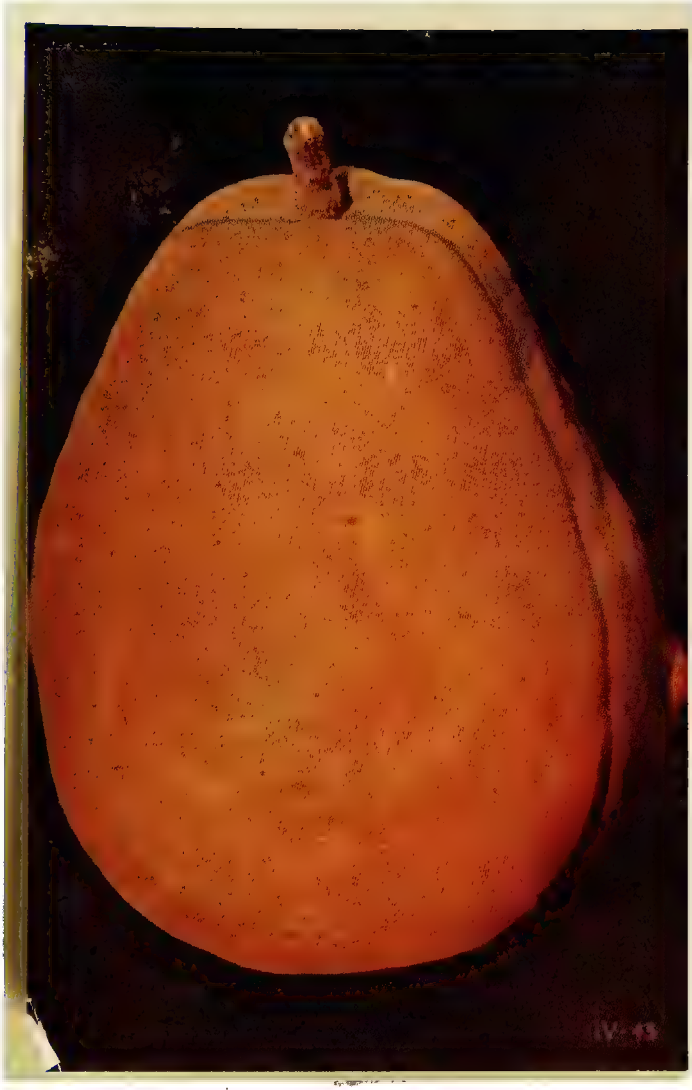
Sir Almroth Wright's inoculation for the prevention of typhoid fever. It is at least within the possibilities that a not dissimilar inoculation may give the tree immunity by developing its powers of resistance, quite as the human subject is given immunity.

Of course the tree has no arterial system that can be inoculated with hypodermic syringe as the human subject is inoculated. But the life of the tree is dependent on the circulation of fluids within its tissues none the less. These fluids are taken in by the roots, and they find their way to the uttermost leaf. So it is conceivable that by proper treatment of the soil about the tree, the tissues of the tree itself might be so altered as to become resistant to the attacks of the bacterial enemies.

### Immunity Through Treatment and Breeding

Nor is this idea altogether theoretical. Experiments have already been made that look to the checking of the growth of the tree by withholding fertilizers and water, that the development of the tender buds and shoots, which are the usual points of attack of the enemy, may be made to take place slowly and thus to present tissue of a less succulent order.

Such hardening of the wood by withholding water has proved effective in the case of some pear orchards in Colorado, where it appears that the



## A Seedling Pear

*This is a seedling pear that departs from the ideal shape, but which has many other qualities that highly commend it. It is large, and of luscious quality of flesh. Owing to its form, and to its lack of color, however, it has not been introduced, but has been used in further breeding experiments in the attempt to develop an ideal pear.*

pear does not really need so much water as it ordinarily receives.

But the effort to give the tree immunity must go even deeper. Induced immunity is valuable, but the ideal condition is that of inherent resistance, bred in the tissues.

Physicians tell us that the all-important thing in warding off bacterial infections in the human subject is the inherent vitality and resistance of the patient himself. In the last analysis, this is the prime essential. A thoroughly rugged organism may be immune to almost every type of bacterial disease. We are told that almost no one escapes infection with the germs of tuberculosis. The ones who show no evidence of the disease are simply those whose tissues are so resistant that the attacks of the bacilli are thwarted.

The horticulturist must take a lesson from the experience of the physician, in particular with regard to the malady we are now considering; for, as we have just seen, the analogy between the pear blight and human infections is almost perfect. So the ideal at which the plant experimenter must aim is the development of a tree that will be immune to the attacks of the bacillus, however freely the germ finds access to it.

My new hybrid pear, thanks to its Oriental heritage, seems to fulfil this condition. The same

thing appears to be true, at least in some measure, of the other hybrids that have the Oriental strain. So there is every reason to hope that we shall be able to develop races of pears, having all desirable qualities of fruit for the different markets, that will be free from the pest that hitherto has made the raising of this fruit a more or less precarious industry.

### Ideals and Possibilities

As to the other needs and possibilities of pear development, not much need be said. Reference has elsewhere been made to the desirability of giving the pear a brilliant color; but this can doubtless be accomplished without great difficulty. It has also been noted that as to size of fruit, as well as in the matter of form, there is little to be desired by way of change.

There is, however, one quality that the specialized pears have markedly lacked. They will keep for a time if plucked while green, and will ripen off the tree. But if allowed to ripen on the tree they decay very quickly after picking. It is obviously desirable that the pear should be given keeping qualities. But here, as in case of immunity to the blight, the solution is already in sight.

Among the varied fruits of my hybrid seedlings, there are some that produce winter pears

that keep quite as well as ordinary winter apples.

These furnish the foundation for future hybridizing and selecting experiments, through which, without question, it will be possible to produce races of pear having all the qualities of flesh that have hitherto made the fruit popular, and with the added property of keeping over winter.

Other possibilities of pear development lying a little farther in the future and therefore somewhat more vaguely outlined, have to do with the hybridization of the pear with the allied fruits of related species. It is well-known that the pear shows, in this regard, a strong disinclination for entering into such an alliance. The pear may be grafted on the quince but it is usually considered impossible to graft it on the apple.

I successfully carried out such a grafting experiment, however, when I was a boy in Massachusetts, the cion being a Seckel pear. But although this grafted cion bore fruit for two seasons, it then died, probably because of the uncongeniality of the alliance.

This experiment shows that there is not complete antagonism between the two species; and the same thing is further demonstrated by the well-known fact that the apple may be grafted on the pear stock; although here also the alliance is


### *The Ideal Pear*

*This is the pear which represents the culmination of Mr. Burbank's many years of experiment with this fruit. It will be seen that the best qualities of the seedlings shown in the earlier illustrations have been combined to produce a pear that is of ideal shape, large in size, and beautifully colored. When we add that the flesh of this pear is of corresponding quality, it will be plain that the fruit justifies the name of "The Test," under which it was introduced.*

not likely to prove fruitful and satisfactory. But of course grafting is only an incidental adjunct of the work of the plant developer. The impulse to progress must come through hybridization and selection. Here, it appears to me, there are great possibilities. I have hybridized the pear and the apple; also the pear and the quince. The seedlings from these unions have sometimes seemed thrifty, but were always infertile. They were highly interesting none the less.

The most successful cross was obtained by using the pollen of the Bartlett pear upon the Gravenstein apple.

The seedlings from this cross were divergent in appearance, and variable as to growth. One of the seedlings grew fully as fast as the ordinary apple seedling, but most of them had a sickly, dwarfed appearance, and some died after having made a foot of growth. Three or four of those that lived were grafted on an apple tree. They maintained moderate growth for several years, but were never healthy or vigorous, and never gave any intimation of blooming.

The results of the crosses between the pear and quince were closely similar. From these hybrids also I failed to secure fruit. Some grew with great vigor for years, while others almost refused to grow at all. In general appearance, and espe-

*Seedling Pear Trees*

*The wild pears have a protective equipment of thorns, as illustrated by the seedlings at the right. These thorns are no longer needed to protect the cultivated pear, and they have been entirely discarded by the best cultivated varieties, as illustrated by the seedling at the left. An occasional seedling, however, still reverts to the thorny type, showing the strong hold of heredity.*

cially in foliage, the hybrids bear a closer resemblance to the pear than to the quince. But many appeared to be fairly good composites of these widely differing plants.

As there are many varieties both of pears and quinces, each having individual characters and diverse hereditary tendencies, an inviting field is open to the careful and patient experimenter in crossing these distinct yet related species. If the right combination can be effected, the results undoubtedly will be profoundly interesting and valuable. Precisely what these results will be, no one can predict. But that new fruits, making most valuable additions to the dietary, may ultimately be thus developed, there is no reason to doubt.

*—The pear and its cousin the apple may well be considered the two orchard trees which are friendliest to man.*

# Fuzzy Peaches and Smooth-Skinned Nectarines

## Two Fruits Which Beg for More Improvement

"MR. BURBANK," said a visitor, "you have taken the thorns off the blackberry bush and the spines from the cactus. Now why can't you take the fuzz off the peach?

"Most of us don't deal much with blackberry briers or with cactuses, spiny or otherwise; but we all eat peaches, and a good many of us would about as willingly bite into a spiny cactus as a fuzzy peach. If you will only take the wool off this otherwise perfect fruit, we will raise a monument to you by popular subscription."

"But nature took the wool off the peach some thousands of years before you and I were born," I answered; "and I have not heard of any monuments being erected in commemoration of the event."

"What in the world do you mean? A fuzzless peach—who ever heard of such a thing?"

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"Everyone has; the fruit that you call a nectarine is precisely that thing—a peach without the fuzz."

"But that does not serve the purpose at all," he insisted. "If the nectarine is a peach that has lost its fuzz, it is also a peach that has lost its flavor. What we want is a fuzzless peach with the true peach flavor remaining."

"Well, I think I shall be able to satisfy you even there before a very great while," I answered; "for I am on the track of experiments that are likely to meet all your requirements in that direction. Even now I have a fruit that is smooth-skinned and yet is unquestionably a peach—not only that, but a peach of excellent flavor. But it is not yet quite good enough to put on the market, and I shall have to carry the experiment a stage or two farther before I am ready to demand that monument."

And then I led the way to a part of the orchard where I was able to show a number of peaches with perfectly smooth skins, some of which are by no means ill-flavored, even though none quite compete with the best peaches now on the market.

My visitor assured me that nothing else that he had seen gave him so much satisfaction or aroused such pleasurable anticipations as this smooth-skinned peach.

*Flowering Peach in Blossom*

***Mr. Burbank's fondness for flowers has led him to experiment largely in the production of fruit trees having beautiful blossoms. The flowering peach here shown is an example of a tree that has been doubly specialized, so to speak, through selection. The Japanese are the pioneers in the production of fruit trees that bear beautiful flowers.***

And I suspect that a very large number of persons under the same circumstances would be of the same mind, for I am told that the aversion to the fuzz of the peach is a by no means uncommon form of phobia.

It might be of interest to inquire just how this curious antipathy to anything so soft and delicate as the structure of the peach's skin was developed. I know men of perfectly stable nerves who cannot touch a peach without experiencing a disagreeable sensation, and who cannot bite through the fuzzy surface without shuddering. And as there seem to be large numbers who experience more or less the same sensation, it goes without saying that there must be some hereditary basis for this curious and seemingly absurd prejudice.

It is somewhat comparable to the fear of the mouse so common with women, or the instinctive dread of the snake that most of us feel.

Just how the peculiar antipathy was developed, would, as I say, be a curious matter for speculation. Here, however, we are concerned with the fuzz of the peach not in its direct relation to human psychology, but in its bearing on the heredity of the peach itself. To the plant developer this is a matter of interest, because linked with it is the question of the way in which the superfluous skin-covering can be eliminated.

## *The Freestone Indian Peach*

*In his extensive experiments in breeding better varieties of peaches, Mr. Burbank has followed his usual custom of going to all countries for material with which to make crossbreeding or hybridizing experiments. This Indian peach has been utilized chiefly because of its freestone quality. The tendency to loosen the flesh about the stone as the fruit ripens is, fortunately, a hereditable quality.*

I speak thus of the fuzz of the peach as being superfluous, but on second thought we cannot be too sure that it really serves the fruit no useful function.

Indeed, the inference should be rather the other way.

At least we may feel sure that unless the woolly coating at some time served a very important purpose, it would never have been developed; or, having been developed, it would not have been retained.

That is assuming, however, that the peach developed this unusual fruit covering in a state of nature, and without the aid of man's selective influence, which it certainly did.

### How the Peach Got Its Coat

If it could be shown that the fuzz was developed only after the peach came under cultivation, and in response to man's wishes, the case would be altered. In that event it might readily be that the fuzzy covering, appearing first as an accidental "sport," had been retained because it pleased the fancy of some plant experimenter, or met the taste of some influential market man—say of Athens in the olden days, or of Rome in the time of its power.

But in all probability the peach had its fuzzy coat at a time vastly more remote than this. It is

**The Exquisite Peach**

*This is one of Mr. Burbank's crossbred peaches, which must be admitted fully to merit its name. It has qualities of flesh that correspond with its attractiveness of form and color.*

almost certain that the coat was developed long before the fruit came under cultivation.

The fair presumption is, probably, that the ancestor of the peach, wandering from one territory to another as all plants do, found itself at a certain stage of its career in an environment where the conditions of moisture and wind and sunshine were peculiarly trying, or where some insect or fungoid or bacterial pest menaced its immature fruit. And in such a case it may readily have chanced that a peach that tended to produce a skin of exceptionally resistant texture, one in which the bloom assumed a more than usually powdery or fibrous character, was given protection against the enemies, and thus preserved where fruit with smoother skin was destroyed.

Under these circumstances, the incipient fuzz on the peach would serve as material for the operation of natural selection, and a race of peaches bearing fuzzy-skinned fruit would presently supplant the tribe of smooth-skinned peaches.

Something like this, I suspect, we should find to be the history of evolution of the fuzzy-skinned peach, could we look with some necromantic microscope into the germinal center of the peach seed and translate the marvelous history of endless generations of peaches, back to the beginning, that is therein recorded.

## *Late Clingstone Peach*

*This crossbred peach has the merit of ripening very late, thus extending the peach season. It also has size, good form, and fine quality of flesh in its favor. The chief defect is that it is a clingstone. This defect may be remedied in the offspring, by combination with a freestone variety.*

There is no such microscope as this, of course. But we can, in a sense, perform the same necromantic feat, and lay bare the mysteries of the history of the evolution of the race of peaches, in a quite different manner.

If you have read the earlier chapters of this work, you will know that the method I have in mind is the familiar one of causing the germ plasm of the peach, with its weird record of past events, to blend with the germ plasm of another tribe of plants having a somewhat different history; in order that the conflict of tendencies thus brought about (as we used to say; or the blending of hereditary factors, to use the popular phrase of the moment), shall bring to the surface and make tangible in the hybrids of a new generation, the traits that were submerged and hidden in the individual plant before us.

And when this familiar yet no less wonderful test is applied, we learn, among other things, that the peach which now holds to its fuzzy coating so tenaciously, at one time had a cheek as smooth as that of any other fruit. For among the offspring that appear as the result of blending peach strains, there now and again is one that bears smooth fruit.

Moreover, the smooth fruit that thus appears is closely similar to another fruit which, from its

general appearance, would be declared by any competent observer to be a close relative of the peach, namely, the nectarine.

So this bit of evidence from heredity—this freak of atavism—may be taken as furnishing substantial evidence that the ancestor of the nectarine was also the ancestor of the peach. Or, stated otherwise, that the peach is in reality a modified nectarine. It may be added that both are undoubtedly modified from a plum-peach-apricot-almond ancestor.

That the nectarine, rather than the peach, represents the ancestral form is witnessed by the fact that the nectarine is rarely observed—at least in my experience—to produce a fuzzy fruit, however closely it may otherwise simulate the peach. And, of course, this evidence is in keeping with the natural inference one would draw from the fact that pulp fruits in general have smooth skins, or skins with at most a delicate bloom quite lacking the texture of the peach's almost woolly covering.

### The Marriage of Cousins

In any event, there can be no question that the peach and the nectarine are very closely related; in fact, they are generally classified as a single species, the trees differing very slightly in any respect, the only difference being in the fruit.

It is probably but a short time, as compared

with the entire stretch of their racial histories, since the two fruits branched from the same stem. And so it is quite to be expected that the two would readily cross. In point of fact, the experiment of cross-pollenizing is so readily performed that it is very often carried out by the bees.

The hand pollenizer may make the test successfully without the slightest difficulty.

I was led to experiment along this line by the recollection of an old peach tree called a "Melocotoon", four of which stood in our home garden in New England, and one of which, as I well recall, had a single branch high up in the tree that always bore a fruit quite different from the peaches with which its other branches were laden. This anomalous fruit, which appeared as a "bud-sport" was in fact a nectarine.

I had learned also that when peaches and nectarines were grown in the same neighborhood, one could never be certain as to which fruit would grow when the seed of either fruit is planted.

You may plant a peach seed and grow a nectarine tree; or, far less frequently, you may grow a peach tree from a nectarine seed.

The explanation, of course, is that the two tribes are constantly intercrossed when growing side by side, through the agency of the bees.

Pondering these facts, I determined to make

## *The National Peach*

*This crossbred peach was named National because of its varied excellent qualities; in particular its adaptability to different climates, making it available for growth in widely different sections of the United States. It is a peach of average size, but of exceptional qualities of flesh. As compared with some other crossbred peaches, it is somewhat lacking in color.*

some definite experiments in hybridizing. I first selected for the experiment the white nectarine and the Muir peach. In 1895 numerous crosses were made, using principally the white nectarine pollen to fertilize the blossoms of the Muir peach, a very hardy, vigorous, abundantly productive variety of the peach that is largely cultivated in California.

The white nectarine has a rich flavor, but it is too acid to eat without cooking. It is of large size, has a large stone, and white flesh, with perfectly smooth white skin. The Muir peach, on the other hand, is very sweet, with firm yellow flesh, and an unusually small, free stone. A tree of this variety is unusually hardy, long-lived, and immune from that pest of the peach orchard, curl-leaf. It may be grown in a large variety of soils in locations where other peaches and nectarines often fail.

The offspring of this union of nectarine and peach in due course came to fruiting age, and in some cases the fruit they bore was found to be of a quality superior to that of any peach or nectarine at that time ever seen. In the second and third generation there appeared a varied company, showing remarkable new combinations of qualities, and anomalies of form, size, color and flavor.


### *The Lemon Muir Peach*

*This seedling of the familiar Muir peach has many qualities to recommend it. It was given the name Lemon Muir because of the lemon tint which is well reproduced in this color photograph, and partly also because of the somewhat lemon-like form of the fruit itself.*

Many of them combined the sweet yellow flesh of the peach and the acid quality of the nectarine, producing delectable and altogether novel flavors.

### Smooth-Skinned Peach Hybrids

There are now large numbers of these cross-bred peach-nectarines on my place, some of them being of the fifth and sixth generation from the original crossing.

Some have a crimson leaf like that of the crimson-leaved peach.

Some that have the characteristic rough stone of the peach, retain the smooth skin of the nectarine. These constitute a smooth-skinned variety of peach such as the visitor with the aversion to fuzzy skin longed for.

First and last, these hybrids show almost all possible combinations of a score or so of qualities as to which the two fruits in their divers varieties differ. Among these there are some that are of such desirability as to make the fruits worthy of introduction, notwithstanding the very excellent assortment of peaches already on the market.

The first member of the hybrid company to be sent out into the world was named the Opulent.

It grew on a vigorous tree that bore abundantly even when quite young, and produced a full crop of superlatively luscious fruit each season, ripening here about July 30th. The fruit has a

*An Unnamed Peach*

*In his extensive experiments in the breeding of peaches, Mr. Burbank has of course produced many varieties that have not been introduced. The picture shows one which certainly looks good enough to eat, and is good enough to eat, but it is being subjected to further tests before its ultimate fate is determined.*

white skin with numerous beautiful dots and shadings of light and dark crimson, and the flesh is pale lemon yellow, suggesting a blend of the deeper tint of the Muir peach and the white flesh of the nectarine. In flavor the fruit has an indescribably delicious quality that in my estimate surpasses that of all other peaches. But it is too soft for long shipment, although having all the desirable qualities of a home fruit. The Opulent has been acknowledged by all who have tested it to be the best in quality of any peach ever produced.

The tree is unusually hardy. It has been cultivated as far north as Canada and has proved able to endure a temperature of 40 degrees below zero, bearing a full crop after other peaches in the same locality were destroyed by the severity of the winter.

Among the numerous seedlings from the Opulent, some are white nectarines pure and simple, some are red or pink nectarines, and some closely resemble the Muir peach. Yet here and there one differs from any known variety of peach or nectarine.

Similar results have been obtained in a subsequent series of experiments, in which the white nectarine was crossed with the early Crawford and peaches of other varieties. These crosses pro-


### Other Attractive Foundlings

*These are examples of yet another variety of peach that is still in the testing orchard. The specimens here shown speak for themselves, and the reader will not doubt that they have many excellent qualities. But Mr. Burbank's fixed rule is that a new fruit must be equal to any already in the market in all qualities, and superior in at least one quality; and it has not yet been determined whether this particular fruit meets this test.*

duced some seedlings of unusual size and good quality. The trees are nearly all resistant to curl-leaf and mildew. As might be expected, the seedlings from succeeding generations differ widely. While nearly all possess one or more desirable qualities, it is rare that any one combines enough good qualities to entitle it to special consideration.

### THE UNION OF PEACH AND ALMOND

Another series of hybridizing experiments, begun about eighteen years ago, used for the original cross the purple-leaved peach and the Languedoc almond.

In the first and second generations, the four or five thousand seedlings produced had green leaves like the almond.

In the succeeding generation, however, there appeared a few seedlings having purple leaves suggestive of those of the peach ancestor. A particularly dark one was saved. As is usual with the peach and almond hybrids, this tree was very fertile. One season I obtained more than 500 fruits from it.

In every respect this fruit was intermediate between the peach and the almond.

About nine-tenths of the seedlings grown from the fruit of this purple-leaved hybrid had purple leaves like the parent plant; most of the others

had leaves of pure green, but a small proportion showed leaves of an intermediate color.

Looking at the row of seedlings from a short distance one would hardly perceive anything but a line of deep crimson or purple. Some of the individual seedlings were much darker than the parent, being fully as dark as the original purple-leaved peach. Most of the seedlings resemble the peach in foliage, but some have longer and more pointed leaves like the almond parent, and these grow more rapidly than the others and have a more upright appearance, in this respect also resembling the almond.

Although the exact parentage of the hybrids of the later generations of this combination of the almond and the purple-leaved peach was not traceable, and although no close record was kept of precise numbers, it will be obvious that the result of the first cross showed that, as between green leaves and purple leaves, in the relations of these two species, the influence of the green leaf was prepotent or dominant.

This is perhaps what one would expect, considering that green is the normal color of leaves, and purple exceptional.

The reappearance of the purple leaf in later generations is, of course, precisely what would be expected of a recessive character.

In any event the reappearance of the purple leaf, fully pigmented, after its submergence, affords another interesting illustration of the segregation of hereditary characters that we have repeatedly had occasion to note in connection with other experiments.

### Cousins From the Orient

Continuing the experiments in peach betterment, I not unnaturally turned to the Orient for the material for further experiments in crossing.

There is a double-flowering peach that has long been under cultivation in China and Japan. It is a slender, willowy tree, generally with drooping branches. The blossoms are about an inch and a quarter across, snowy white, or pink, or deep crimson. They are quite double, resembling little roses, and they are produced in great profusion. The trees, however, are dwarfed and ill-shaped; they are also peculiarly subject to mildew and curl-leaf.

The fruit of the flowering peach is somewhat almond-shaped and unusually pointed. It has flesh of light color and a large stone. The fruit is hardly edible even when cooked.

I have taken particular pains to cross this double flowering exotic with standard and the new cross bred peaches, and have succeeded in producing some fine varieties. The most striking

## Big String Nectarines

*The nectarine is in effect a smooth skinned peach. It is believed that the two fruits are really identical superficially, and have only somewhat recently been modified through selective breeding. Nevertheless there are obvious differences in the peach and the nectarine, and there is opportunity for interesting experiments in crossbreeding. Mr. Burbank has taken full advantage of these opportunities, and this picture shows one of his many interesting results.*

result, up to date, was a tree bearing a rich, rosy, pink blossom, fully two inches in diameter, which is produced in greatest abundance, on trees of strong growth, which show no propensity to droop like the oriental tree, and which appear to be resistant to curl-leaf and mildew.

This large, vigorous, healthy tree, bearing a profusion of bright pink flowers, has obvious ornamental value. But in addition to this, this new variety bears an abundance of fruit, large in size, and almond-shaped, which is of fairly good quality when fresh, although scarcely to be compared with standard peaches, but which when cooked is probably unsurpassed by any peach, having a delightful almond flavor.

This particular variety is a cross of the crimson flowering oriental peach and the hybrid Muir peach, and is a product of the first generation.

Especial interest attaches to the results of crossing the oriental peaches with peaches of the occidental stock because, as in the case of so many other fruits, the peach of the Orient is widely divergent from the European type, although doubtless both have the same remote origin. As in the case of our other chief fruits, the native home of the peach was doubtless southern and central Asia and eastern Europe, and there was a double migration in prehistoric days which re-

*Bully Nectarine*

***The name may be a trifle slangy, but there is something about the fruit that seems to justify the name. It is a blunt, round, prolific, sturdy, luscious, wholesome fruit —in short, a bully nectarine.***

sulted in stocking China with peaches of one type and Europe with quite another.

The peach most commonly grown in the United States is usually spoken of as belonging to the Persian race. The Chinese type of peach has been variously tested in California, and for the most part found wanting. The chief defect of the Oriental variety is the pointed almond shape of its fruit, and susceptibility to mildew and curl-leaf.

It will be recalled that the oriental pear showed precisely the qualities of hardiness and resistance to disease that the oriental peach notably lacks. The difference, in all probability, is to be explained by the different treatment the two fruits have received in their Asiatic home. The pear has been developed for its fruit, and the oriental taste demanded certain qualities of firmness and perhaps slight astringency that might be said to be in keeping with the natural character or propensity of the wild fruit.

But in the case of the peach special development has taken place along the line of flower production. Doubtless more attention has been given to this than to the question of fruit. And as with most specialized races of plants, there are incidental defects due to the selective breeding for a single quality, and the overlooking of other qualities.

But whatever the explanation, the fact remains that the Chinese peach is not to be looked to as introducing the elements of hardiness and virility.

Nevertheless in the southern states the Chinese peach, which seems to be of tropical origin, thrives and is even quite as popular as the Persian strains.

Fortunately some of the varieties of the European stock are vigorous and hardy growers. But the development of new varieties that will be absolutely resistant to the diseases to which the peach is peculiarly subject is a task that invites the plant experimenter. I have already referred to the success in this regard that attended some of my hybridizing experiments.

My new peaches, named respectively the Leader and the National, both of them crosses of the Muir and Crawford stock, have been entirely free from any suspicion of mildew or curl-leaf.

But there is demand for a great variety of peaches, and it is highly desirable that the average stock of this important fruit should be greatly improved in regard to virility.

That the peach may under favorable conditions live to an old age and continue in bearing is demonstrated by exceptional trees that are known to be half a century old, yet still retain their vigor and productiveness. When we contrast with this the familiar fact that the average peach orchard

bears only for a relatively short term of years—often only ten or fifteen at most—the vast economic importance of this possible improvement will be quite obvious.

### A Stoneless Peach?

As to the fruit itself, there is one opportunity for improvement that is particularly inviting—the possibility of producing a stoneless peach.

The desirability of such a development, from the standpoint of the peach consumer, requires no demonstration. From the standpoint of the tree itself, a reduction in the stone would be highly important. It costs a peach tree to produce a pound of stones probably as much as to produce many pounds of pulp.

The drain on the vitality of the tree in producing the stone that it no longer needs must take from it in some measure the capacity for production of fruit pulp that it might otherwise have.

The hybridizing experiments with the almond have influenced the stone of the fruit in a suggestive way. Some of my hybrid peaches have a kernel that is almost as sweet and edible as the kernel of the almond. As yet I have not secured a peach having really good quality of flesh combined with the edible seed. But that this combination might be effected, if one were to select for it, admits of no question.

## A Peach Triumph

*Here is a peach seedling, crossbred, that is as good as it looks. It represents one of Mr. Burbank's triumphs in the betterment of a familiar fruit. It is not a new creation, but it is improved all along the line. Perhaps it comes as near to the ideal of what a peach should be as any fruit ever grown.*

And a peach retaining its recognized qualities of flesh and having at its center an edible nut like the almond with thin shell would obviously be a desirable acquisition.

Such a combination of fruit and nut would be doubly desirable if the stone that surrounds the kernel can be eliminated as it has been eliminated in the stoneless plums.

As yet very little has been accomplished in this direction. There is, to be sure, a Bolivian peach which is remarkable in that it has a globular stone very little larger than a good-sized pea. The fruit itself is of intermediate size and poor quality; moreover, it is produced sparsely, and the tree is peculiarly subject to the peach maladies. The fruit has been thought hardly worth crossing with our ordinary peaches on account of its inferior qualities, yet the diminutive stone suggests that it would be possible by such crossing to produce a superior peach having an exceedingly small stone.

Time and patience would, of course, be required to carry out such an experiment, but its results could hardly be in doubt.

It is possible, however, that the experiment of reducing the size of the peach stone will prove less inviting than the attempt to remove the stone altogether. My success in producing the stoneless plum points the way to a possible development

*Nectarine-Peach Cross*

***This picture has peculiar interest as illustrating the great diversity of form that may be shown by fruit of mixed heritage growing on the same branch. As one parent is smooth-skinned and the other fuzzy, interesting experiments may be carried out in noting the way in which these qualities are transmitted to different members of the progeny, particularly in the second generation.***

through which the peach also may at some time become stoneless.

And it is not unlikely that the Bolivian pea-stone peach, which has shown a propensity to minimize the stone, may be utilized advantageously in the course of these experiments.

It is true that no stoneless peach of whatever quality is known, comparable to the original wild bullace of Europe, that gave the opportunity in the development of the stoneless plum. But, fortunately, I have been able to demonstrate that the peach may be hybridized with the plum. I have made the hybridization successfully with both the Japanese plum and the Chickasaw plum.

Should it prove impossible to hybridize the peach directly with a stoneless plum, one of these peach-plum hybrids might perhaps be made to bridge the gap.

No doubt a vast deal of ingenuity would be required to find the combination that would work out successfully. But it was shown in the case of the stoneless plum that it was possible to re-assemble the good qualities of the fruit of one parent and the stoneless condition of the other in the progeny of the hybrids of later generations.

There is no obvious reason why the same thing might not be done in the case of the peach.

The possibility seems the greater because the

## *Nectarine-Peach Cross*

*This picture shows the crossbred fruit cut open, revealing the stone. It will be seen that in these specimens the stone is unduly large, and that the fruit clings to the stem. Where peaches and nectarines are growing in the same neighborhood, crossbreeding experiments are often made by the bees, without human interference.*

peach has been cultivated in so many different regions and for so many different purposes that it is highly variable. Its affinity with other stone fruits has been illustrated over and over in the story of hybridizing experiments already related.

So it seems at least within the possibilities that a way may be found to combine the stoneless condition which has now been bred into the germ plasm of one member of the stone-fruit family, with the recognized qualities of the peach, in a hybrid—produced, no doubt, only after a series of experiments extending over many years—that will represent the ideal of a stoneless peach.

If the qualities of the almond seed were also bred into the combination, the final product—a fruit having the matchless flavor of the peach, a perfectly smooth skin, and a stoneless seed of delicious edible quality—would assuredly be the paragon of orchard fruits. That such a fruit will ultimately be produced there can be little doubt. When we reflect on the long gap that separates the peach of to-day from its primitive wild ancestor, we need not regard such further development as that just suggested as being very formidable.

But, of course, there is a *time* element that cannot be ignored.

So here, as with other orchard fruits, it is only such experimenters as have the gift of patience

who can enter the field with prospect of success.

Granted that endowment, however, and a reasonable comprehension of the principles of plant breeding already presented, any intelligent amateur may undertake experiments in the further education of the peach that may well lead to results of the highest interest and of notable economic importance.

*—The peach with its luscious meat, the nectarine with its smooth skin, the almond with its delightful kernel, and the stoneless plum with its unsheathed seed—who will breed these together and thus produce a unique and valuable fruit-nut?*

## *A Beautiful Seedling Apple*

*Every orchardist is aware that seedlings grown from any standard variety of apple may show the utmost diversity of size and form and color and flavor. Any one may begin breeding experiments with the apple by planting seeds of any stock. There will be abundant opportunity for selection among the seedlings. Mr. Burbank has experimented very extensively with this fruit, and some of the results of his experiments are shown in succeeding pictures. The present picture shows one of the most beautiful seedlings, but one which, unfortunately, has certain defects that have prevented its introduction.*

# The Apple—A Fruit Worthy of Still Further Improvement

## New Apples and How to Make Them

IF YOU were to look in Regan's book on the Nomenclature of the Apple you would find that about eight thousand varieties of this fruit are listed by name,—not counting synonyms, of which each variety has several.

And you would receive assurance that the catalogue includes only such selected varieties as have attracted more or less attention in this country alone.

After scanning this list you might be excused if you felt disposed to turn your attention to some other fruit. An orchard product that already possesses eight thousand named varieties may not seem at first glance to offer a very good opening for the plant developer. It may reasonably be supposed to be a fruit that is already pretty well developed.

And in point of fact there is no disputing that

the apple is a well-developed fruit. There are varieties of almost every supposable size and color and flavor and degree of early or late ripening, as the case may be, and of keeping quality. Yet it would be going much too far to say that nothing remains to be done. There are plenty of opportunities for the plant developer in dealing with this fruit, as I shall attempt to show in a moment.

But before taking up that aspect of the matter in detail it will be worth while to clarify the situation by a few words of comment as to the eight thousand varieties of apples that make such an imposing array on the pages of the cataloguer.

### Varieties Versus Individual Types

The average purchaser and consumer of fruit probably has very vague notions as to what is the real status of the particular variety of apple that especially appeals to him.

He finds his favorite fruit—be it Baldwin or Northern Spy or Greening or Gravenstein or what not—in the market year after year at a given season. He sees that each fruit is always of approximately the same size, and color, and flavor. The differences between the named varieties are so radical that they could not possibly be overlooked. A greening apple, for example, bears much less superficial resemblance to a snow apple than it bears to a quince; and the average purchaser

might be excused if he supposed these two apples, along with numberless other specialized varieties, to represent forms as distinct from each other as, let us say, blackberries are distinct from raspberries or oranges from lemons.

But in reality the status of even the best market "varieties" of apples is quite different from this. It would scarcely be an exaggeration to say that each "variety" of apple manifests the peculiarities of an individual rather than those of a race.

We have already had our attention called more than once to the fact that the apple, in common with most other cultivated fruits, does not breed true from the seed.

It has been pointed out that we could not secure an orchard of Baldwins by planting the seeds of the Baldwin.

In a word, the fact has been emphasized that the conventional and necessary method of propagating the different varieties of apples is by budding or grafting, or by the equivalent method of sprouting slips or twigs. And attention has furthermore been drawn to the fact that this method of propagation may be regarded as the division of an individual that has the property of restoring lost parts and continuing its growth indefinitely rather than propagation through a succession of generations.

It has been suggested that all trees that represent a particular variety of cultivated fruit—say all Baldwin apple trees or all Seckel pears—are separated parts of the original tree of corresponding variety, and not descendants of that tree.

Holding to this point of view, then, it is clear that the different "varieties" of apples might, from a biological standpoint, be classified as individuals rather than as races.

Their inability to reproduce themselves in offspring through the ordinary processes of generation denies them the rank of races or varieties proper, let alone the rank of species.

And after all the difference in appearance between two apples that rank in the catalogs as specific varieties is not greater than we sometimes see manifested between brothers and sisters of a human family. A man more than six feet tall with florid complexion, light blue eyes, and flaxen hair, certainly represents a type quite different from that represented by a woman less than five feet tall with swarthy complexion and black eyes and hair. Yet we sometimes see such divergences as these between a son and daughter of the same parents.

### Origin of the Diversified Types

We shall gain a somewhat truer conception of the meaning of our apple catalog, then, if we

*Mr. Burbank's South Apple*

***This crossbred seedling, while lacking some qualities, notably of size, that characterize other seedlings in Mr. Burbank's orchard, it has merits that have on the whole made its introduction desirable. It is acknowledged to be a fruit of great merit in the regions where it can be successfully grown.***

think of each listed variety as having the status of an individual rather than that of a race.

The diversity of individul types becomes explicable if we consider the history of their development. The apple has been under cultivation for some thousands of years. It has qualities that have made it a favorite with successive generations throughout the entire period. It has been taken everywhere with migrating races of men—it was brought to America, for example—until it girdled the globe and found its way almost to the Arctic Circle.

The different races of apples thus developed have been from time to time intermingled through migrations of the peoples who cultivated the fruit, many of whom, doubtless from the earliest period, carried it with them in a dried state on their voyages, and thus incidentally transported its seeds and carried it into new regions.

The varieties thus brought together have been cross-pollenized by the bees, and so the tendency to vary and to keep a great variety of ancestral traits in evidence has been perpetuated.

Finally, in modern times there has been perhaps more attention given the apple by the horticulturist than to any other single orchard fruit. The qualities of the apple and its adaptation to all tastes, zones, and soils naturally account for

## *Winterstein Apple*

***This well-known variety of apple is considered by Mr. Burbank to be in some respects superior to almost any other of the familiar cultivated varieties. He has used it very extensively in his crossbreeding experiments, and its blood enters into the heritage of nearly all of his best seedlings.***

this. And the result is recorded in the present day lists of the cataloguer. Whenever, through the chance blending of favorable ancestral strains an exceptional individual has appeared, cions have been cut from that individual and grafted on other trees, and new cions cut from this and again grafted, until the fruit of this individual grows on so many different trees and in so many different regions that its peculiar qualities are thought of as representing an established variety rather than an individual personality.

But if you will gather the seed from the apples of a single tree of even the best market "variety" in any given season, and will plant these seeds, you may have, when the seedlings come to fruiting, new "varieties" of apple, each differing from all its fellows, in such profusion that you may, if you so desire, exhaust your ingenuity in finding new names and publish a catalog of your own with a list of eight thousand or so "varieties" of apple that no one hitherto has ever seen or heard of.

That simple but rather startling fact brings into sharp relief the difference between the meaning of the word "variety" as applied to such a fruit as the apple and the meaning of the same word as applied to races of plants in a state of nature.

## *Burbank Seedling Apples*

*These seedlings, particularly the one at the left, show the influence of the Winterstein parent. They are of complex heritage, however, and have many characteristics that cannot be traced to the Winterstein. The specimens here shown represent an intermediate stage in the breeding experiments, and they have not individually been introduced or named.*

The seed of a plant of a valid wild variety (sub-species), or the seed of a hundred plants of that variety intermixed, will produce a generation of offspring which, though they number thousands or millions, all bear striking resemblance in their essential qualities of shape and leaf and flower and fruit to the parents from which they sprang and to one another.

This is the fundamental difference.

It is a difference that should be borne constantly in mind when we use the convenient word "variety" in connection with an orchard fruit. Perhaps it is unfortunate that the word has been applied with this double meaning; but it is obviously convenient, and if properly interpreted it may be used without danger of confusion of ideas.

### From Germ Cells to Apples

That the potentialities of numberless new varieties lie hidden in the pollen grains and ovules of a single flower-cluster is a thought that makes strange appeal to the imagination of the intelligent plant developer.

When he pollenizes a flower he is bringing together two germinal microcosms each of which, rightly viewed, is a universe within itself.

He is dealing with individual life histories and with the histories of races.


*The Roman Beauty Apple*

*This excellent variety of apple shows a good deal of diversity, particularly as regards color, in individual specimens, as the two here shown will suggest. The fruit has qualities that commend it, both for its own sake, and as a parent in breeding experiments for the development of new varieties.*

He is performing, as I said before, the most marvelous of all experiments.

He deals with the same matter with which the chemist deals in his laboratory; but with this matter aggregated into new and wonderful combinations which alone make possible those responses to the environment and that primeval capacity for growth and of self-reproduction that differentiates what we call living tissue from the matter out of which it is constructed.

But if the plant experimenter must be allowed to indulge in such visions he must none the less remember that the microcosm of the germ cell represents after all only a transitory and transitional phase in the life cycle of the organisms with which he deals.

He may love to ponder over the mysteries of the nucleus of the germ cell, but he cannot offer that nucleus for sale in the market.

The tangible product of his investigations, the one that will have commercial importance, must find representation in germ cells that have infinitely multiplied until their descendants are piled together in such unthinkable numbers that they make up the structure of visible plants, and,—to meet the exigencies of the case under consideration,—of visible and tangible fruits of the orchard.

*Seedling Apples*

*If you wish to raise new varieties of apples, it is quite possible to do so without practicing cross-fertilization. The cultivated varieties are so mixed in their heritage that nothing more is necessary than to plant seeds of almost any variety to secure a great number of aberrant new types. The ones here shown are seedlings of the Winterstein.*

To be quite specific, and to bring us back directly to the practicalities of the subject in hand, the development of the germ cell must have led to the production of the particular fruit called the apple.

What, then, practically does there remain for the plant investigator to do in the apple orchard?

With eight thousand varieties of apple on the market, just how shall we come in competition and produce a new variety that will commend itself as having some points of superiority to any existing? Unless we can do that, it assuredly is not worth while to cumber the market with a new apple. There are enough inferior fruits already in the field. Let us by all means refrain from adding to their number.

What has been said suggests that the task ahead of us, in the perfectionment of the apple, does not lack difficulties. As a tangible illustration of the extent of these difficulties, I may note that I have grown on my experiment farms not fewer than 50,000 seedling apples, from the best standard varieties, since 1886, when I first definitely turned attention to this fruit; and that out of the entire number a single dozen now stand out somewhat prominently as being superior.

There are others, to be sure, not yet come to the fruiting age, that may surpass any yet pro-

duced in a combination of good qualities. Some of the individuals improve in certain points from year to year, and reveal new strength in certain valued characters, while others may fail to fulfil their early promise. The test must extend over a series of years, after the trees have commenced to bear, and each new strength or weakness in every direction must be noted with unflinching fidelity.

With the record of my own experiments as a guide, let us briefly glance over the field, to gain such clues as we may to the opportunities that still lie open for the betterment of this fruit.

### A Few Practical Hints

Great emphasis has been laid on the fact that apples do not breed true from seed. It should be noted, however, that some varieties are much more nearly fixed than others. The Fameuse, Gravenstein, Garden Royal, and Golden Russet may be named among those that tend to reproduce a good many of their characteristics in their seedlings. Yet from any of these there may be produced apples showing almost every possible variation as to size, shape, acidity, flavor, and color. And so the growth of seedlings will be undertaken only for the purpose of securing new variations or to supply stocks on which to graft cions from old ones.

In raising apple seedlings to obtain improved varieties it is best to select seed from some one standard apple that already possesses most of the good qualities sought in the improvement, because comparative tests are more easily made from one variety than from mixed seed. There is much variation among different varieties as to keeping qualities of the seed and characteristics of the seedlings. Seedlings of the Baldwin, for example, are peculiarly subject to mildew; seedlings of the Newtown are usually rather slow and slender growers.

As a general rule it may be said that the seeds of winter apples have a greater tendency to produce winter apples than summer apples, whereas summer apples are almost as likely to produce winter varieties as to reproduce their own qualities as to time of bearing.

Sweet apples are quite often produced from the seeds of sour ones and vice versa.

The Yellow Bellflower produces a large proportion of seedlings good in most respects, and this is true also of the Newtown Pippin, Hubbardston, the Rhode Island Greening, Roxbury Russet, Haas Queen, William's Favorite, Swaar, Rambo, Fameuse, Lyscom, Alexander, Palmer, and Wagener. Especially fine seedlings have been obtained from the Garden Royal, Fameuse, Golden Russet,

### *More Seedling Apples*

*These are seedlings of a quite different type from those shown in the preceding picture. They show the mixed heritage that characterizes most of the Burbank seedlings. Although of excellent quality, the ones here shown have not been introduced or specifically named.*

Wagener, and in particular the Gravenstein and the Newtown Pippin. Usually the weak point in Northern Spy seedlings is poor quality, notwithstanding its own exquisite quality.

One can be almost certain of producing some early bearing seedlings, which will yield fruit of good quality, though lacking in size, from the Golden Russet, Garden Royal, or the Fameuse, and without raising a great number of seedlings.

Apple seeds, like all other fruit seeds, germinate more readily if not dried too thoroughly. The best method is to place them when fresh, after thorough cleaning, in a box of slightly moist sawdust or coarse sand, moist enough to keep the seeds from drying, but not moist enough to cause germination or to induce mold or decay. Kept in this way in a cool place until desired for planting, they will germinate with unusual vigor.

If the apple seeds are wanted in large quantities, crush the fruit in a cider mill and wash the seeds from the pomace. When only a few seeds are to be taken from rare specimens of apples, the seeds are usually removed by hand. The seeds may be planted in the open field as early as possible in the spring in rows three or four feet apart, if cultivation is to be done with horse plows. Ten to fourteen inches apart is sufficient space for hand cultivation.

Details as to methods of planting and care of the seedlings have already been given in a separate chapter and need not be repeated here. No special cultural directions are required in growing the apple seedlings. They are cared for on my farms very much as peas and beans are cared for, and they are as easily grown.

It may be well, however, to inspect the young seedlings occasionally and to remove all weak or slow-growing ones and those having slender stems and thin, small leaves; and in particular any that show the slightest evidence of mildew.

It is not desirable to treat seedlings that are grown for the production of new varieties with fungicides; the persistent aim should be to produce trees that are thoroughly resistant to fungoid diseases.

The seedlings that show large, thick leaves and thick, fat, prominent buds placed not too far apart, combined with stocky, short-jointed, juicy wood, are the ones most likely to be valuable.

Let us emphasize again that in fruiting the seedlings an enormous amount of time and valuable space can be saved if they are grafted upon large bearing trees. I am accustomed to take one or two good cions from each of the selected seedlings at the end of the first season's growth, grafting them into a bearing tree on branches a quar-

ter-inch or at most a half-inch in diameter. Thus placed, they will begin bearing in from two to four years; whereas if placed upon the large branches a much longer period would be required.

By this method I have tested as many as 526 varieties by actual count at the same time upon a single tree.

Thus twenty thousand or more varieties may be tested at once on a single acre. The same trees may serve in this way over and over indefinitely.

It would be well if fruit growers in each geographical section would raise and test new seedlings, and also introduce and experiment with new varieties produced elsewhere, aiming always to select those best adapted to the requirements of the particular locality. In this way many localities where the apple cannot be grown today might produce thriving orchards.

### Making Hardy Apples

The apple is relatively hardy, but improvement is still possible in the way of producing varieties that will stand the excessive cold of our northern winters. The work of crossing hardy Russian apples and also the hardy American crab with the better varieties of apples is now being carried on quite extensively, especially in Iowa. By this means some good varieties have been produced that are especially adapted to withstand the

**Nameless Beauties**

*These Burbank seedlings are also nameless, although they would merit introduction were it not that there are already so many excellent varieties of apples on the market. As it is, they have proved useful in further cross-breeding experiments.*

extremes of temperature of the northern Mississippi Valley, and others are in prospect.

Especial efforts are being made, also, to develop varieties that will be immune to the attacks of the insect pest known as the woolly aphis, which does great damage in apple orchards, especially on heavy soils and in moist climates. This pest is relatively harmless to the treetops, but does great damage when it infests the roots of a tree.

Because of the immunity of the pear to the attacks of the woolly aphis, I have made many attempts to find a variety of pear that would serve as stocks on which to graft apples. In a very few cases the grafts have taken well at first, but the final result was a failure, from a commercial standpoint. It is possible that a variety of pear will eventually be found which will be congenial to the various varieties of apples; and, if so, the problem of combatting the woolly aphis will have been solved.

My experiments consisted in growing seedling pears to get new varieties on which to graft the apples. This is probably the only way to approach the subject, for attempts have been made with practically all the existing varieties of pears, and in every case the result has been failure.

Fortunately there is one well-known variety of apple, the Northern Spy, that is aphis-proof. Trees

**Two Fine Specimens**

*The chance that there may be among your seedlings some trees that bear apples like these should give peculiar interest to the experiment in the production of new varieties. These are Burbank seedlings of heritage so complex it would be difficult to trace their precise antecedents.*

of this variety are never injured by these insects, even when planted beside trees seriously infected. It has been found expedient, therefore, to graft other varieties on roots of the Northern Spy, and an orchard that has practical immunity to the attacks of the aphis may thus be produced.

Unfortunately the seedlings of the Northern Spy do not generally inherit this quality of resistance to the aphis, so it is necessary to grow the roots from cuttings.

Apple twigs do not root very readily, but if cuttings from vigorous Northern Spy branches are placed in the soil and allowed to grow for a year or longer they develop a good root system and the roots may be severed into small pieces, each of which will produce a stock upon which grafts of any variety may be placed.

### Hybrid Apples

I have experimented very extensively, as already noted, with the crossing of different familiar varieties of apple, and have produced several new varieties that have been deemed worthy of introduction.

But my most interesting experiments have had to do with the wider hybridization in which one or another variety of cultivated apple has been crossed with a related species. In endeavoring to introduce new traits I imported in 1890 all of

**More Nondescripts**

*Illustrating the wide diversity among apples of the same inheritance. The apple has been so long under cultivation and has been developed under such diversified conditions of soil and climate, that its germ plasm contains miscellaneous factors of great diversity. Just which ones of these factors will make themselves manifest in any given case, it is impossible to say, and the uncertainty adds zest to the work of the fruit developer.*

the best varieties of apples theretofore originated in Australia and New Zealand.

It was necessary to graft these cions into older trees to test the fruit, and some very curious results were observed.

Most of these new varieties from another hemisphere appeared to be surprised to find the winter over so soon and the spring now opening upon them. Some varieties immediately put out buds and blossoms and continued to do so at intervals throughout the summer; others stubbornly declined to bud or blossom until nearly the beginning of the following spring. For two or three years thereafter all seemed quite confused and disturbed by the transposition of the seasons; but ultimately they became adjusted to the new order of things. One or two of them have proved to be unusually fine apples, and are now thriving well in northern Sonoma and Mendocina Counties.

About 1894 I began experimenting with our native crabs, crossing them with pollen of our best cultivated apples, more to see what would result than with any expectation of securing improved commercial varieties.

One striking result was produced by using the pollen of the Gravenstein. Numerous seedlings were thus produced from this little native crab.

*Large and Toothsome*

***These Burbank seedlings represent several generations of selective breeding and general encouragement. They taste as good as they look, and they are worthy of a place in any orchard or on any table.***

Strange to say, among the seedlings of the first generation was an apple which was fully as large as the Gravenstein and very much like it, except that, though quite good for a short time just before ripening, it changed rapidly to a punky or mealy state. Others were about halfway between the two species in size, color, quality, growth, and other characteristics, both of trees and fruits in all variations.

But among the second-generation seedlings raised from these hybrids some fairly good apples were produced. In form, some almost duplicated the Gravenstein itself; very few of them resembled the true wild crab type, except that nearly all had a certain crablike acidity and lack of flavor.

Some of these hybrids are still growing on my Sebastopol farm. No one of them gives promise of being worthy of introduction, but it is not unlikely that something of value may be developed from this stock by further hybridizations and selections. The wild crab has certain qualities of hardiness and prolific bearing that might be of value in combination with the fruiting qualities of some cultivated variety. This, at all events, is a line of investigation that offers opportunity for further tests.

Doubtless the most interesting of these hybridizing experiments with the apple tree are those in

## Gold Ridge Apple

*This Burbank cross-bred apple, unlike a good many others that have been shown, does not reveal the characteristics of the Winterstein, at least as to color, although it has strains of that apple in its heritage. Mr. Burbank thinks so well of this particular variety, that he has given it the name of his Gold Ridge Farm, where his chief orchards are located. It illustrates the possibility of developing valuable new varieties, even of this most widely cultivated of fruits.*

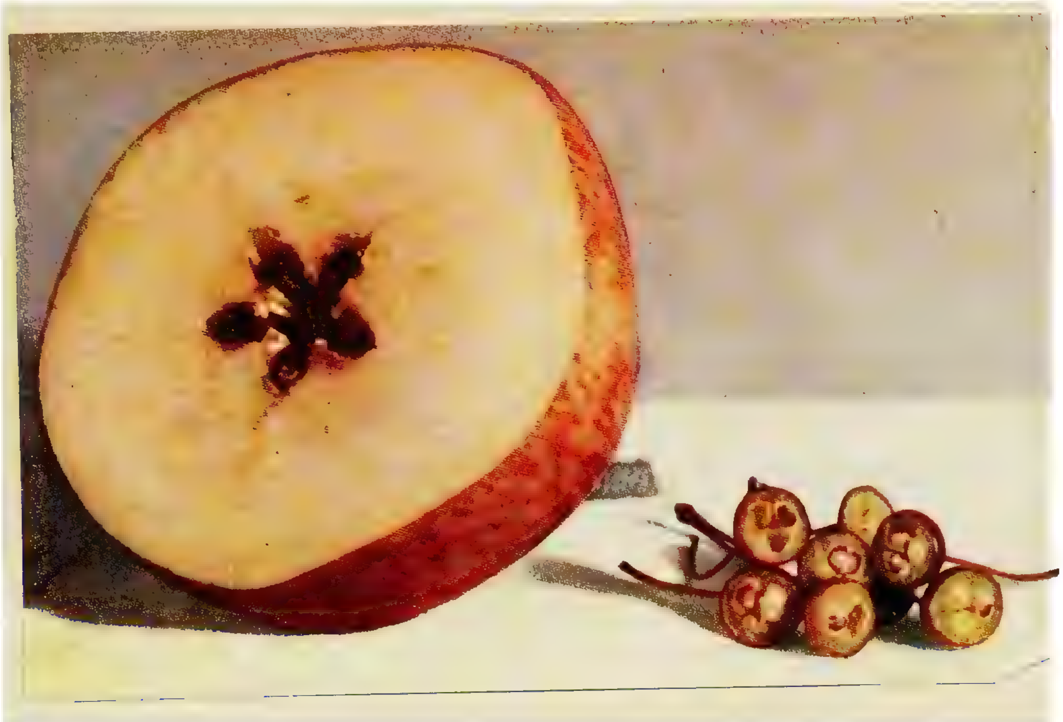
which this species was crossed with the quince and with the pear.

I have grown numerous seedlings from a cross of the apple and the common quince, *Cydonia vulgaris,* and also the giant Chinese quince, *Cydonia sinensis.* This cross was made both ways in both cases. This is a cross between genera.

Some of these hybrid seedlings grew quite rapidly. The growth was generally peculiar, being compact and stubby, and often with an unhealthy appearance, especially towards the last of the season. The foliage and bark most often resembled the quince.

I expected good results from these interesting hybrids, but not one ever produced even a blossom. The developments were the same in all seedlings, however the cross was made. After a few years they would decline and die, whether grafted on the quince or the apple or growing on their own roots.

Several varieties of apples were also crossed with the Bartlett and other pears. This is also a bigeneric hybrid, and the result was in the end similar to that of crossing the apple and the quince. Most of these seedlings were abnormal in their growth. They were generally dwarfed, but in some cases exceedingly rapid growers were produced, especially when the Bartlett pear was



*Extremes of Development*

*The Burbank apple at the left is one of the largest apples ever grown; whereas the wild apples at the right are fruits of insignificant size. Note that the small apples are nearly all seeds, whereas the large apple is nearly all pulp. No more striking example could be given of the possibility of modifying a fruit through selective breeding. The wild apple may still be of service as a hybridizing agent in the development of hardy strains of cultivated apples.*

crossed with the apple. But none of them gave any indication of producing blossoms, let alone fruit. These, like the quince-apple hybrid seedlings, being only cumberers of ground which was needed for other purposes, were destroyed.

It will be seen, then, that nothing of practical importance came of my experiments in hybridizing the apple with its remoter cousins. Nevertheless the proof that such hybridization is possible must be regarded as highly interesting. It seems by no means unlikely that further tests along these lines might result in revealing some varieties of these various fruits that would combine more advantageously and produce fertile offspring.

As I have said in another connection, there is perhaps no opportunity open to the amateur fruit grower that suggests greater possibilities of really important discoveries than this. Out of a union of apple and quince or apple and pear might very possibly come a new fruit that would constitute an acquisition of the very greatest value to the orchardist.

But even if the practical or economic results should prove meagre, such a series of experiments might still have a large measure of scientific interest, more than justifying the time and labor devoted to them. So little work—relatively speak-

*Getting on in the World*

*Three big cross-bred Burbank apples are here shown in comparison with three tiny wild apples, the latter probably not very different from the parent forms from which the cultivated apple originated. Note the similarity in the outward appearance of the fruit, notwithstanding the enormous disparity in size.*

ing—has hitherto been done in this line, that the field may be said to be almost virgin. Opportunity beckons the would-be plant developer alluringly.

And, fortunately, this is a case where the material for experimentation is freely available. Apples, pears and quinces grow in thousands of dooryards. Thousands of men and women might test their mating possibilities. There will be stimulus of novelty and the lure of unknown goals in such an endeavor.

*—There are eight thousand named varieties of the apple, but who shall estimate the uncounted opportunities for further apple improvement?*

# THE TRANSFORMATION OF THE QUINCE

## WHAT WAS ONLY A COOKING FRUIT NOW DELICIOUS RAW

IT IS said that Henry Ward Beecher once gave a formula for cooking the quince. His rule was this: Take one quince, one barrel of sugar, and sufficient water.

This rule was given, I hasten to explain, at a time when my Pineapple quince had not been developed.

Had Mr. Beecher tasted one of these perfected quinces he would have seen that his joke no longer had its former force. For my Pineapple quince, and one or two others that have been developed even more recently, retain very little of that acrid quality which Mr. Beecher's barrel of sugar was designed to hide.

On the contrary, the new quinces, when fully ripe, are to be compared in texture of pulp and in edibility with some of the best apples, rather than with their quince forebears; and at the same

time they retain the matchless flavor that made the quince a favorite fruit for jellies and preserves even when its other qualities made it altogether inedible before cooking.

Indeed, the new fruit not only retains the indescribable but exquisite savor of its tribe, but has taken on quite pronouncedly the flavor of the pineapple, justifying its name in the estimate of most persons who have eaten it.

The transformation thus effected in the quality of the quince has been brought about through a series of experiments that began as long ago as 1880. When I first gave the matter consideration I reflected that the quince, although it had been under cultivation for at least two thousand years, had been distinctly neglected by the horticulturist. There was a prevailing idea that the quince tree would thrive on neglect, and that the inherent qualities of the fruit were such as to place it hopelessly beyond the reach of experiment except as material for cooking.

But I could see no good reasons why the quince should not be improved somewhat as the apple and pear had been.

So I commenced work by obtaining seeds of all the best strains of quinces, including among others the Orange, Angus, Portugal, Rae's Mammoth, West's Mammoth, and Champion. All of these are

varieties derived from the common species which the Romans called *Mala Cydonia,* or Cydonian apple, because an improved variety came to them from Cydon, in Crete. From this old Roman name we have for the common quince the scientific name of the present time, *Cydonia vulgaris.*

### First Successful Matings

One of my earliest experiments was to cross the Orange quince with the Portugal quince.

The Orange type is generally much more productive than the Portugal, and the fruit is larger and more pleasing in form, being nearly round and quite smooth. It is also of a more attractive color. On the other hand, the pear-shaped Portugal quince, although having an objectionable rusty coat, is of a better quality, having a very pleasing flavor when cooked.

It seemed certain that from the combination of these two varieties it might be possible, by subsequent selection, to produce a quince superior to either.

Seedlings from this cross of Orange and Portugal quinces were raised extensively for several years.

Large trees upon which to graft and test them all not being available, the selected ones were set out on the Sebastopol place rather closely, in rows about 4½ feet apart. Although a thorough test

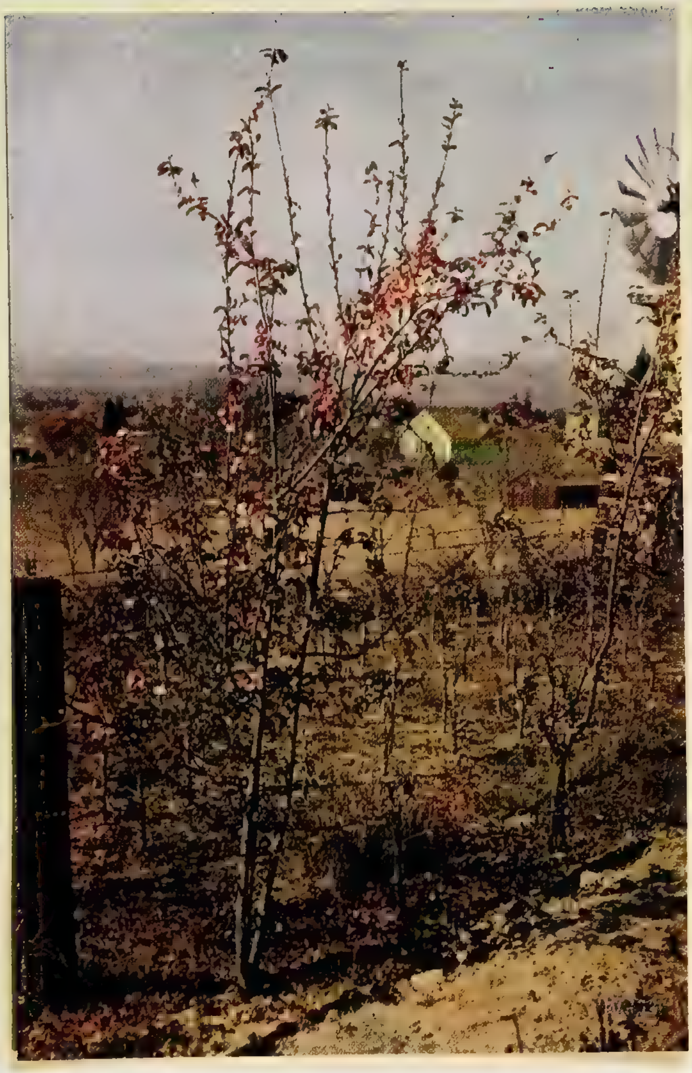
could not be made in this way of all the varieties, it was possible to make a very fair comparative test. The poorer seedlings were from time to time removed, leaving space for better development of those that remained. Later some of the trees whose fruit was not promising were used as stocks on which to graft hybrid pears and other seedlings.

By this method I have tested probably fifty thousand quince seedlings.

The first important result of this experiment in crossbreeding was the production of a quince of large size from a seedling produced by pollenizing a Portugal quince with the Orange quince. Among my seedlings one individual showed marked superiority over its fellows even in the seed-bed, by its unusual vigor and the rich green of its large, finely formed foliage.

Among the entire lot of 700 cross-bred seedlings, this one alone proved really valuable.

The fruit it bore received the Wilder Medal at the meeting of the American Pomological Society at Washington, D. C., in September, 1891. It was so generally admired and promised to be so valuable that Professor H. E. Van Deman, then Chief of Division of Pomology, U. S. Department of Agriculture, was pleased to have it named for him. The Van Deman quince inherits great productiv-



*The Japanese Quince*

***Like a good many other fruit trees, the quince has been modified by the Japanese in the direction of brilliant foliage and beautiful flowers. It thus becomes an ornamental shrub in addition to its fruit-bearing qualities.***

ity, size, nearly globular shape, smooth skin, and attractive color from the Orange quince, while it received its spicy flavor and tenderness from the Portugal. It has continued to be extremely prolific, and an unusually strong grower, and at the present writing, 1914, it is quite generally pronounced the best of all quinces, and the only quince worth raising in the eastern states. It has proved to be of remarkable hardiness and productiveness under the most adverse conditions.

Under favorable conditions the Van Deman produces three distinct crops each season in California.

The first or main crop ripens on my experiment farm during the latter part of September. The fruit of this first crop is of extremely large size, often being over five inches in diameter, and weighing 25 ounces.

The second crop ripens about November, and the third a month later. With these later crops the fruit is usually much smaller. But all are of good flavor, texture, and quality. They bake as quickly as apples, and are tender when thus prepared.

The dried or canned fruit retains the much desired quince flavor.

At the time when the Van Deman quince was introduced, in 1893, I had growing for compari-

### Fruit of the Japanese Quince

*The Oriental taste in fruit is different from the Occidental. As a rule the fruits developed in the East are somewhat harder in texture, and more acrid in quality than those that have been developed in Europe and America. There is less difference in this regard, however, in the case of the quince than with some other fruits, notably the pear. The Japanese quince has been used by Mr. Burbank in crossbreeding experiments in the development of his perfected varieties.*

son trees of all the other varieties above mentioned. But no one of them bore fruit at all comparable to the new variety.

The new tree, in addition to being a very prolific bearer, also had the habit of early-fruiting.

Trees two years old have been reported as bearing fruit.

From Florida a Van Deman quince is reported that took on eight feet of new growth within one year from the time of planting. In Washington two trees in their third season bore twenty fine quinces weighing from twelve to fourteen ounces each as their first crop, and a little later a second crop declared to be quite equal to the other.

### Seedling Tests and New Crosses

I had, of course, made crosses between various other varieties in the quince orchard and in due course developed other seedlings that showed valuable characteristics.

I learned by experience to be able to select seedlings of the quince, as of other fruit trees, by observing the character of the leaf and stem.

Seedlings having leaves that are large, thick, dark green, and glossy, and that show prominent rounded buds and upright branches with thick, bright wood are those that may be expected to produce the largest and finest fruit.

Wcrthless seedlings are known by the oppo-

*Foliage of the Japanese Quince*

*The thick, fibrous leaves of the Japanese quince add to the beauty of the tree. The branches, however, are likely to be spiny. The quince appears to represent a somewhat more primitive type of plant than most other of our cultivated fruits. Mr. Burbank suggests that the cultivated quince of to-day is in about the condition of development represented by the pear of the Roman time.*

site characters. Seedlings having small, knotted, twisted wood; slender, small, sharp buds; long joints; woolly, wild-looking leaves, and irregular rambling tendency of growth should be rejected, as they will rarely produce fruit of any value.

There are notable exceptions to these rules of correlation between twig and foliage and fruit-quality, but, as a rule, the qualities just noted may be depended upon to serve as useful guides.

My second important new quince was grown as a seedling from Rae's Mammoth. It was, I am confident, a third generation seedling of a cross between Rae's Mammoth and the Portugal quinces. Its immediate pollenate parentage is not a matter of record, as a great number of cross-bred quinces were under observation at the same time, and specific record was kept only of the first pollenations.

This offspring of Rae's Mammoth was at first called the Santa Rosa, but was subsequently re-christened by the introducer as the Child's quince. It is remarkable for its great size and productiveness, for beauty of form, and for its pale lemon yellow or almost white skin; also for the tender flesh and delicious flavor of its fruit, and the diminutive size of the core.

So fine-grained and tender is the fruit, and so free from the harsh acidity of the old quince, that

it is equal to some popular apples for eating raw, and fully equal to the best apples or pears when baked, stewed, or canned. It will cook as tender as the best apple in five minutes. Moreover, it makes a superior light-colored dried fruit.

In form the fruit is somewhat intermediate between the Portugal and Rae's Mammoth, inheriting from both parents; but in quality it is far superior to either. This new variety has been rather extensively distributed in the eastern states. The only complaint heard of it in the colder climates is that it does not bear so well as in California, but this is the case with all quinces. The soil and climate of California are peculiarly hospitable to this fruit.

### The Pineapple Quince

I have elsewhere called attention to the fact that once a tendency to variation has been introduced by crossing among plants of a given company, the effect appears to be cumulative.

Thus opportunity is often given in later generations for selections that will lead to relatively rapid progress along the desired line of development.

Such was the case with the quinces. As selection proceeded one generation after another, the tendency to improvement became more pronounced. The new varieties already secured were

a very great advance upon their progenitors, but there ultimately appeared a seedling that produced a fruit far superior even to the very good ones already introduced.

This superlative variety, which appeared as the culminating product, for the moment at any rate, of fifteen years of selective breeding, was the one referred to at the beginning of this chapter.

Because of its peculiar flavor this new quince, as already stated, was named the Pineapple.

It is additionally remarkable for the early-bearing and great productiveness of the trees, for the large and uniform size of the fruit, which is moreover exquisite in form and of a pleasing light lemon yellow color.

Everyone knows that the ordinary quince cannot be eaten raw with any degree of satisfaction, nor with any expectation of personal comfort in the immediate future. Even children, voracious and unexacting as are their appetites, will scarcely eat a common quince.

But the Pineapple quince when thoroughly ripe rivals the apple as a fruit to be eaten raw.

It will also cook as tender as the tenderest cooking apple in four and one-half minutes. No other quince previously known can be cooked so quickly. It makes a delicious jelly with a strong, pure pineapple flavor. The jelly, indeed, is far superior to

that made from any other quince, and in the estimate of many it is superior to that made from any other fruit.

The Pineapple quince, moreover, is probably the first variety to be profitably shipped from California to eastern markets.

In 1910 Mr. H. A. Bassford, one of the largest growers of California, shipped this variety in ordinary twenty-pound plum crates. The earliest shipments sold at auction for $3.50 per crate. Later shipments brought $1.50 per crate.

### A Practical Shipping Fruit

I mention these practical details because the value of the quince as an orchard fruit for shipment to distant markets has been very little recognized. Doubtless the forbidding qualities of the ordinary quince are responsible for this lack of popularity. But now that the Pineapple quince has been introduced, there should be an entire change of popular attitude toward this really admirable fruit.

I may add that I have even more recently found among the seedlings one that rivals the Pineapple, and which has qualities that fully justify its introduction as another new and distinct variety.

This newest of my quinces—called the Burbank—is somewhat larger than the popular Orange quince and of much better form. It is as smooth

as an apple, having completely dropped the objectionable habit of producing wool on the skin. The tree is vigorous; it grows in fine form; and it is an early and astonishingly prolific bearer.

The fruit has the cooking qualities of the Pineapple quince, and is superior for drying and canning, and quite unrivaled except by the Pineapple for the making of jelly.

### Testing Remoter Cousinships

It goes almost without saying that I did not carry the work with the quince far before I undertook to introduce new blood from more remote sources.

All the varieties hitherto named are descendants of European stock, and are of the same species. But the quince, like the other orchard fruits, has Oriental representatives,—races that migrated eastward from their Central Asiatic home while the parents of the European quince were migrating westward. In China and Japan there are quinces that are listed as belonging to three different species, named *Cydonia sinensis* *C. japonica,* and *C. maulei.* All of these are quite different from the European quince as to growth, foliage, and fruit.

As early as 1884 I began making hybridizing tests with these Oriental quinces.

Particular interest attaches to the experiments

## Chinese Quince

*The Chinese quince somewhat resembles a cucumber. It has no qualities that commend it to the Occidental palate, yet it might prove serviceable as a hybridizing agent in the production of new varieties of quince.*

in which the first-named member of this Oriental trio was used. This is popularly known as the Chinese cucumber quince, sometimes called *Pyrus cathayensis,* the Cathay pear.

In its general appearance this Chinese tree is a small, upright grower, quite unlike the ordinary quince. It is not hardy in the northern United States. The leaves resemble those of the apple or pear more than those of the quince. They turn scarlet in the fall. The flowers for which the tree is mostly grown vary from pink to crimson, making a gorgeous display in the early springtime. The fruit is variable, but is usually long, green, very hard, bitter, and uneatable however prepared, but quite fragrant.

In shape as well as in size the fruit suggests a large, full-grown, white-spine cucumber. It has usually a smooth, though sometimes netted waxy skin. A single fruit from it may weigh more than two pounds.

It will be clear from this description that the Chinese quince, or Cathay pear, differs very widely from the European quince. Its fruit is wholly inedible, yet there is no reason why this might not be made over into a profitable and delicious fruit. It is merely a fruit that has retained the qualities, undesirable from the human standpoint, of its remote ancestors. Perhaps it is not much worse to-

day than the common quince was in the time of the Romans.

In hybridizing this peculiar fruit with the common quince I worked with an open mind, anxious to see what result the experiment might bring forth.

The pollen of the common quince was applied to the pistils of the Chinese species. Pollenation was successful; the appearance of the young seedlings grown the following season left no doubt of that. A glance showed that a certain proportion were hybrids, and even when they first broke the soil they presented much larger cotyledons of a different color from those of either parent.

These seedlings were carefully planted in open ground at Sebastopol with some uncrossed seedlings of the Chinese quince in the same row for comparison, the hybrids, however, being given the choice of soil and location.

We have previously learned that hybrids usually grow more vigorously than uncrossed seedlings, but the case of these quinces proved a very notable exception to this rule. At the end of two years the Chinese quinces of pure stock ranged from eight to twelve feet high, while the hybrids, which had been given more room and the best soil, were dwarfs only six inches high, some of them even less.

The foliage of these curious miniature trees was generally a composite, somewhat suggestive of each parent. But in a few instances plants showed leaves much shorter and more rounded than those of either parent, and having the edges coiled back in a semi-circular form. This peculiar coiling of the leaves was probably due to the fact that the mid-rib was inclined to grow more rapidly than the edges of the leaf.

Unavailing effort was made for two years to stimulate the growth of these interesting hybrids.

The pure bred Chinese quinces in the same row came in due course to the time of fruiting, but the hybrids showed no propensity to flower, and the tallest were less than a foot in height when their uncrossed relatives had grown to the height of ten or twelve feet.

Transplanting to orchard soil and special cultivation appeared to have no effect on the dwarfs. The experiment was made of grafting some of them into old quince trees of each of the parents. Some of the grafts grew and had rambling, spiral-shaped branches, but they stopped growing when they had attained a length of two or three feet. Grafting appeared to give them somewhat enhanced powers of growth, but, like the hybrid seedlings from which the cions were cut, they remained absolutely sterile.

No bush or tree of the entire lot put forth a single blossom.

### Other Dwarfs Recalled

It is interesting to recall, in connection with the curious result of this experiment in hybridizing the quinces of widely varying species, the results of my hybridization of the California and Persian walnuts.

It will be remembered that the hybrids thus produced were of extraordinary growth, but that they produced very few nuts, and that among the seedlings of the second generation there were many trees of dwarfed growth, suggesting the quince hybrids.

We found reason to believe that the curious result of hybridizing the walnuts might be explained on the supposition that the parent forms had diverged almost to the point of mutual antagonism. They had not varied quite to the point where their offspring were sterile, but they were approaching that limit.

The quinces of the experiment now under consideration had diverged one stage farther. They are still within the limits of affinity that permit cross-fertilization, but not within those that permit the production of fertile offspring. Their case is rather to be likened to that of our petunia and tobacco hybrids, which, as the reader will recol-

lect, were lacking in virility and produced no blossoms. The similar case of the motley hybrids made by crossing various members of the rose family with their cousin the dewberry will be recalled. Also the strange progeny of the strawberry and the raspberry.

The Chinese-European hybrid quince, then, in its dwarfed growth and its sterility merely illustrates the principle of growth that we have previously seen manifested with various other plants.

But the extreme dwarfness of the progeny gives an element of added interest. It would be worth while, could time be found for it, to make more extensive hybridizing tests along the same lines. Possibly some other strains of the two species than those employed might prove to have slightly greater affinity. In that case it is conceivable that a new race of quinces might be produced that would bear fruit of a new character and give us an interesting and perhaps valuable addition to the rather small list of orchard fruits.

In this connection I may refer again to the experiments in which I hybridized the quince and the apple, and to others in which the quince and pear were similarly united. The story of these experiments has been told in earlier chapters, and no detailed account of them need be given here. It suffices to repeat that the hybrids in each case

*Van Deman Quince*

***This was the first of Mr. Burbank's important quince productions. It was descended from an original cross between the orange cross and the Portugal quince. It took the Wilder medal at the meeting of the American Pomological Society in Washington in 1891; and was named after Professor Van Deman, then head of the Department of Pomology of the U. S. Department of Agriculture. It is very prolific, hardy, and is regarded in many parts of the East as almost the only quince worth raising. Its productivity, size, shape, smooth skin, and attractive color are inherited from the orange quince; its spicy flavor and tenderness from the Portugal.***

failed to blossom; hence that the experiment, quite as in the cross with the Chinese quince, came to no result of practical value.

But here, again, it should be borne in mind that more extensive experiments in hybridizing these related species might give us a combination that would be slightly less antagonistic.

It goes without saying that a fertile hybrid between quince and apple or between quince and pear would be a fruit of altogether exceptional interest and of the most inviting possibilities. The experiment of hybridizing these common fruits may readily be made by the amateur, and there are few simple hybridizing experiments that are more attractive as to their possible results or more instructive from a scientific standpoint.

### Tests With Japanese Quinces

The two remaining Oriental quinces have already been named as *Cydonia Japonica* and *C. maulei*. It should be added that the latter is probably to be considered as a sub-species. Japanese quinces do not bear very freely, and their fruit has a great variety of forms, and is of such extreme acidity as fully to justify Beecher's celebrated formula—which, indeed, is said to have been suggested by an unfortunate experience with the Japanese quince.

There is great diversity of bloom among

## *Santa Rosa Quince*

***This was Mr. Burbank's second important new quince, and was grown as a seedling from Rae's Mammoth, crossed with the Portugal quince. It is remarkable for its great size and productiveness, for beauty of form, and for the tender flesh and delicious flavor of its fruit, and the diminutive size of the core. It was rechristened Child's Quince by the introducer to whom it was sold.***

established varieties, the flowers ranging in color from pure white to bright scarlet and deep crimson. Some of them are double. The tree is raised for ornament only. The bushes are aflame with leaf buds early in the spring. A little later they light the landscape with their gorgeous array of deep crimson, scarlet, pink, and yellowish or white blossoms. Again, late in the autumn, they are brilliant with bronzed leaves, and present fruits of curious and interesting forms.

This, obviously, is a very different tree from the common quince. It seems so distinct that I have never attempted to hybridize the two. But I have crossed the various Japanese quinces among themselves.

The crossbred seedlings vary widely in foliage, blossom and fruit. Some of the fruit produced was as large as ordinary apples, and of varying shape. Where experiments were made with the sub-species *C. maulei,* there was greater promise than in the case of the other flowering quinces. This sub-species is a more abundant bearer than the others, and its fruit is of less objectionable quality.

The uncrossed specimens of this sub-species are low, spiny shrubs, not more than two or three feet high, with short, stiff, spiny branches, which are often woolly when young. The bushes are multi-

### *The Pineapple Quince on the Tree*

***Mr. Burbank's Pineapple Quince, the culminating effort of fifteen years of selective breeding, combines the good qualities of the other quinces with especial properties of its own. It has the flavor of the pineapple, and has such qualities that it may be eaten raw like the apple. It will cook as tender as the tenderest cooking apple in four and one-half minutes. The tree is extraordinarily precocious, sometimes bearing fruit when only four months old. Tiny trees of the pineapple quince are sometimes borne to the ground with their weight of relatively colossal fruits.***

plied readily by division; that is, from rooted suckers, which spring up from the parent plant. The flowers, which are usually borne in abundance, are of a bright orange-scarlet. There are races of the sub-species that have variegated leaves tinged with delicate pink and white.

This type of flowering quince has much to recommend it as an ornamental shrub. Moreover, my hybridizing experiments, as far as they went, indicated that the *C. maulei* has valuable latent possibilities as a fruiting shrub.

From the many thousand seedlings a good many promising specimens were obtained. Some of these produced large, handsome, light crimson blossoms, and extremely large orange-like waxy golden fruit in the greatest profusion. These quinces, indeed, are among the handsomest of all fruits. They always attract attention by their peculiar form, golden color, and exquisite fragrance. The flesh, however, is usually hard and very acid, though not unlike some varieties of the common quince.

The extreme hardiness of this species, and its great productivity make it a very valuable parent for crossing with other allied varieties. It would be highly interesting and perhaps important to experiment in crossing these shrubs with the common quince. If the cross could be effected, it is

*Pear Seedlings Grafted on Quince Stocks*

*The quince root system makes an ideal stock for grafting, and the pear thrives admirably on this stock. More than a thousand such grafts are to be found in the space shown in this picture.*

not unlikely that very valuable betterments could be brought about. It is at least within the possibilities that a quince might be developed that would be superior in various ways to even the best of the European varieties. But doubtless a long series of experiments would be necessary to attain this goal.

Whatever the precise steps through which the further development of the quince is brought about, there can be no question that this fruit has a very important future. It has been neglected in the past, and the fact of its tendency to vary toward the wild type, demonstrates the comparatively slight improvement that has been made in it through artificial selection. But the production of the new quinces that I have described opens a broad new field in quince culture. The first steps in improvement have sufficed to show that the fruit is responsive.

The quince of to-day is, indeed, a half wild product that has waited long for its opportunity.

It remains for the fruit growers of tomorrow, working with the partially developed product in hand, to see that the possibilities of this unique fruit are realized. So hardy, prolific and generally attractive a tree should make especial appeal to the amateur orchardist. The fact that the quince has been neglected, and thus has abundant possi-

*The Medlar—A Cousin of the Quince*

*The Medlar, known to the botanist as Mestilus, is a native of central Europe. There is a single species only, but there are several cultivated varieties. The fruit is too acid for most tastes, but after being mellowed by the frost it is relished by those who care for acid fruit. It is hardy as far north as central New York in the eastern states, and of course throughout California. It is worthy of more attention than it has received from the American fruit developer. Mr. Burbank has grown it, and has made tentative efforts at its improvement, but these have not been carried to a conclusion.*

bilities as yet unrealized gives it additional attractiveness from the standpoint of the amateur.

In case of apple or pear or peach we have to do with fruits that have been carefully studied in thousands of experiments generation after generation. Even so, we have seen that there are still good opportunities for further experiment.

But how much larger and, so to say, more accessible are the opportunities in case of a fruit that has been generally ignored as has the quince. Why not avail yourself of these opportunities?

*—It remains for the fruit growers of tomorrow working with the partially developed product in hand, to see that the possibilities of this unique fruit are realized.*

# The Apricot and the Loquat

## An Opportunity for the Experimenter

"THE only use I have for the apricot," said a visitor, "is to supply a flavor for soda water; but that use justifies the fruit's existence. No other flavor can match it."

Doubtless my visitor spoke facetiously, but we may all agree with her that there is no other flavor quite to match the flavor of the apricot. Fortunately, however, there are uses to which the fruit may be put in addition to the one she suggested.

Otherwise it would not be possible to find a market for the two hundred million pounds or so of apricots that California raises each year.

In point of fact the uses of the apricot are quite as varied as those of most other fruits.

It is an admirable table fruit in the fresh state for those who live near enough the orchards to secure it. It is in considerable demand by canners who find ready sale for the fruit when preserved

in this way. But the chief demand, and the one that gives the apricot its real economic importance is based on the exceptional qualities of the fruit when dried.

Something like three-quarters of the entire output of the California orchards is preserved in this way and shipped as dried fruit to all parts of the world, and brings about the highest price of any tree fruit under cultivation.

A perhaps clearer estimate of the value of the industry may be gained if we recall that there are nearly three million apricot trees in California orchards. Indeed, this state has a practical monopoly of commercial apricot growing.

Nowhere else in the world is the fruit of corresponding economic importance.

The apricot has been cultivated from an early period of history, like the allied orchard fruits, and it has been grown more or less extensively in America for many years. But it is a fruit that is greatly restricted as to the regions in which it can advantageously be cultivated. The fact that there are very large areas of California where it thrives, sufficiently explains the virtual monopoly in the growth of this fruit that the Pacific Coast enjoys.

### Why Apricot Culture Is Difficult

The difficulty that the apricot grower encounters may be said to center on a single char-

## *Siberian Apricots*

*The Siberian apricot dries on the tree, or after falling to the ground, when it may be preserved for a long period. This naturally dried fruit is sought out by the Nomadic tribes, for some of whom it provides an important element of diet during the winter season.*

acteristic of the tree—the extreme sensitiveness of its blossoms to the slightest fall in temperature.

The apricot tree itself under proper conditions is relatively hardy and extremely productive. It is long-lived, and it attains great size. Moreover, it sends out a very extensive root system; demanding plenty of room, and justifying the demand by its increased production when the trees are not crowded. It continues to grow for many years, constantly extending its root system; so that some orchardists recommend planting the trees originally twenty feet apart and then, after a number of years, as the trees increase in size, removing every other one, thus securing a forty foot space for the roots of each tree.

In the matter of pests that attack it, the apricot is relatively favored. It is on the whole a very healthy and vigorous, as well as very beautiful tree.

But the sensitiveness of its blossoms to the slightest chill has hitherto put a restriction upon the spread of the tree beyond the sub-tropical zones, except in such a territory as that of California, where, because of exceptional topographical conditions, a sub-tropical climate prevails even at relatively high latitudes. There are extensive areas of the middle and eastern states, well toward the north, where the apricot tree may be

grown without difficulty, but where no fruit can be produced because the blossoms are invariably blasted by the frosts or near-frosts that are sure to come after they are put forth.

It is obvious, then, that this fruit presents a very specific and unusual problem for the plant developer.

In case of many other fruits, to be sure, it is desirable to increase hardiness; but with no other fruit that we have hitherto considered is it so preeminently desirable to focus on this single object. For in the case of no other is there so striking a disparity between the roots and the blossoms as regards the climate to which they are adapted.

### Making the Apricot Hardy

The idea that naturally suggests itself to the plant developer is that of selective breeding, in which the individuals chosen are those that have shown themselves relatively able to withstand cold.

These, of course, can readily be selected in any region along the outer limits of the apricot's present zone of productivity, by merely noting the exceptional individuals that produce fruit in the season when their fellows are rendered infertile by the frost.

Seedlings grown from these relatively hardy

plants would, on the average, tend to manifest exceptional hardiness; and by successive selection through many generations it would thus be possible, without question, to modify the sensitiveness of the apricot blossom in such a way as to adapt it for cultivation far beyond the limits of its present range.

Of course such selective breeding would be subject to the usual difficulties and complications that attend the development of any new or exceptional quality in an orchard fruit.

Here, as elsewhere, there are complications due to the fact that the fruit will not grow true to type from seed. In this regard, however, the case of the apricot is somewhat more favorable than that of most other orchard fruits, because this species has been less widely cultivated, and is therefore less complex as to its hereditary tendencies than most others.

Moreover, it is fairly easy in the case of the apricot to predict the qualities of the fruit from observation of the very young seedlings. In general the buds and leaves and wood in the first season give one a fairly good idea as to what size and quality of fruit the future tree will bear.

On the other hand, the apricot has a peculiar habit of sending out a young shoot, and then postponing further growth until the buds set and

## *Japanese Apricot*

*The Japanese apricot bears a small fruit of very poor acid quality, and used only for cooking. It is not an abundant bearer, and has few qualities that can commend it. But it crosses readily with the cultivated apricot, and Mr. Burbank suggests the possibility that in later generations such a progeny may develop unexpected qualities.*

ripen, and this complication may make the choosing of the seedlings a more difficult matter than it is in the case of apples, pears and peaches. For when the growth is checked in this manner the buds may become turgid and the leaves of unusual size on some plants, suggesting great possibilities, whereas, in point of fact, these plants may have no greater intrinsic merit than others that have continued their growth and so will show at the moment smaller buds and leaves.

These complications must be very carefully taken into account in choosing seedlings to save for the development of improved varieties.

The general rule that large leaves, full buds, and large short-jointed stems indicate individuals that will bear large fruit of fine quality must be constantly regarded, but the complications introduced by the anomalous habit of growth just referred to must not be overlooked.

### Can the Microscopist Help?

In carrying out a series of selections with the idea of developing a race of apricots with blossoms resistant to low temperature, there is unfortunately little to be expected from crossing different varieties of this species, because all existing varieties have been cultivated under more or less the same climatic conditions.

Indeed, the outlying forms to which one would

## Japanese Apricots Cut Open

*The picture shows the relatively large size of the stone, and suggests the inferior quality of the flesh of the Japanese apricot. This oriental fruit, while lacking in the qualities that are prized in Europe and America, may prove valuable because of its hardiness in developing new races of apricots through hybridization. It represents a different species from the European apricot.*

naturally appeal are chiefly natives of Asia Minor, Palestine, and Persia, and while they might serve a useful purpose, if hybridized with races now growing in America, in giving a tendency to variability and perhaps also an added virility, it is hardly to be expected that they bear hereditary factors that would greatly aid in the particular matter under consideration, because of the warm climate to which they and their ancestors have been habituated.

Nevertheless, the experiment is well worth making for we know that there are latent qualities in the germ plasm of almost every race of plants that are revealed only through hybridization, and the presence of which would otherwise be quite unsuspected.

In any event there are differences to be observed between individual apricot trees as to the relative hardiness of their blossoms. So material is at hand, with or without hybridization, from which to begin the work of selection.

Doubtless this work might be carried forward much more rapidly if we had a clearer knowledge as to what the precise anatomical conditions are that are associated with extreme sensitiveness of the blossoms.

We know that some blossoms (those of certain Japanese plums, for example) may retain their

### *Foliage of the Apricot*

*The leaves here shown are from one of Mr. Burbank's improved apricots. With the apricot, as with other fruit bearers, Mr. Burbank was able to make selection in the case of seedlings by examination of the foliage and of the buds. Leaves of a rich deep color like those here shown, and fat, well-rounded buds, indicate qualities of tree that will make a good fruit bearer.*

fertility even when subjected to freezing temperature; being able to live even through snow storms, in contrast to the apricot blossoms which wither under influence of the lightest frost.

But no elaborate studies have been made to determine whether this difference is associated with anatomical differences of structure, the knowledge of which might guide the plant developer.

That such differences really exist is suggested by the observed fact that the leaves of very hardy varieties of apples, for example those grown in Siberia, have exceptionally deep layers of epidermal cells to give protection to the less hardy cells that make up the bulk of the leaf. Possibly some similar modification of the cells may account for the resistant quality of blossoms that are observed to be able to withstand frost.

### The Microscope May Help

If such is really the case, the microscopist might come to the aid of the practical fruit grower, pointing out to him the particular trees in his orchard that tend to produce flowers having their structure thus favorably modified.

This method of selection would have obvious advantages over the method of planting trees at random in the colder regions, and waiting the selective influence of frost.

## Apricot and Seed

*This is an improved variety of apricot, the result of selective breeding. Further improvement in the way of decreasing the size of the stone is desirable, however, and no doubt this can be brought about by careful selection, with or without hybridization.*

If the fruit grower could gain such information as this in advance, thus planting only the hardier individuals and subsequently making selection of the best among these, he might obviously hope to advance with greater rapidity. And as the task at best is a tedious one, the plant developer should welcome any aid that may be offered, from whatever source.

As yet, however, we have no assurance that definite assistance can be given us by the microscopists. It may be that the physical conditions that determine hardiness or sensitiveness in the flower are dependent on molecular arrangements that lie far beyond the limits of microscopic vision.

In that case, we shall be obliged to depend upon the old method of selection, picking out plants that have proved somewhat hardier than their fellows, and being on the alert at all stages to discover the correlations as to color or form of stem or leaf that are associated with hardiness of blossom, that these may aid us in making early selection among our seedlings.

### Seeking Aid From the Plum

I have said that the plant experimenter who attempts to give us a race of apricots with blossoms resistant to cold can perhaps expect little aid from crossing the existing varieties of apricot.

*The Seed of the Apricot*

*The apricot is, of course, a near relative of the almond, and the relationship is suggested by the stones and seeds here shown. With the apricot, however, the stone is a waste product, and the desirability of decreasing its size has already been suggested. A stoneless apricot, comparable to Mr. Burbank's stoneless plum, will perhaps some day be developed.*

Fortunately, however, there are possibilities of wider hybridizations that give far greater promise.

There are varieties of Japanese plums that will stand hard freezing every morning from the time the buds start until the fruit is of good size. With ordinary plums such freezing absolutely prohibits the development of fruit, and the apricot, of course, cannot withstand even a single light frost.

The resistant quality of the Japanese plum, then, marks it as a plant having in pre-eminent measure the precise quality that the apricot most conspicuously lacks.

So the question at once arises as to whether it may not be possible to hybridize the apricot and the Japanese plum and by so doing breed into the apricot strain the quality of hardiness, just as we have seen specific qualities bred into other plants by similar hybridization.

Fortunately it is possible to make such a cross. Reference has already been made to the new fruit called the Plumcot that I produced a good many years ago by making use of this particular combination. A full account of the methods involved and the difficulties overcome in producing this very unusual hybrid will be given in a subsequent chapter.

It will then appear that the plumcot is to all intents and purposes a new species of fruit.

It combines the qualities of the plum and the apricot, but in itself it is neither plum nor apricot.

So while the plumcot has exceptional qualities of its own, it does not solve the particular problem with which we are at the moment concerned. We are seeking, not a new fruit, but an apricot having a particular quality that the present apricot lacks.

And the question of the moment is whether there is a probability that after blending the strains of the Japanese plum with its hardy blossoms and the apricot with its peculiar qualities of fruit, it may be possible in subsequent generations to reassemble the qualities in such a way that we would have an apricot retaining the fruit qualities of its apricot ancestor, but combining with them the hardiness of blossom of its plum ancestor.

Were the plum and the apricot a little less distantly related the question would admit of a ready answer.

It would then be almost certain that we could, by a series of selective breedings, produce the desired combination from union of the materials at hand. But the plum and the apricot, as the qualities of the hybrid plumcot show, lie so far apart that their progeny tends to reveal a blending of characters rather than a segregation of unit characters. So it is somewhat less certain than it otherwise would be that the unit characters of the

two fruits may be segregated and re-assembled in the way desired.

Nevertheless I am disposed to think that this result may prove attainable. There are considerable variations between the different plumcots. Some of them tend to vary in the direction of the apricot, and others in the direction of the plum. By breeding with reference to a particular set of qualities—in this case the restoration of the apricot qualities and the retention of the hardy quality of bloom—it would probably prove possible to segregate and re-assemble the qualities now blended in the plumcot in such a way as to give us a true apricot. Enough has already been done to convince me that this is possible.

Such being the case I see no reason to doubt that by careful attention to the question of hardiness of bloom at all stages of the experiment our redeveloped apricot might be induced to retain this quality, a heritage from its Japanese plum ancestor, while retaining also the peculiar qualities of flesh and texture and flavor that are the hall-marks of the apricot.

We shall have occasion, perhaps, to revert to this aspect of the subject more in detail in discussing the plumcot with regard to its various possibilities of improvement. Here it is enough to call attention to the fact that the hybridization

### A Burbank Improved Apricot

*This picture suggests the qualities of this improved apricot, notably its succulent and juicy flesh, and the relatively free stone. It is to be observed, however, that the stone is still larger than is to be desired. The color of the exterior of the fruit is not important, because the apricot is almost altogether used for drying. With fruits marketed in the fresh state, the color is an important item, many people buying fruit quite as much for its appearance as for its taste.*

of the apricot with the plum offers at least a possible solution of the vitally important problem of the development of a cosmopolitan apricot.

Perhaps there is no single problem of orchard fruit development that offers possibilities of greater economic importance.

### Mating With Oriental Cousins

As to other hybridizations, we may add that there is a quite different species of apricot growing in Japan, known as *Prunus mume*, which may possibly be of value in the development of new races of apricots, either with reference to the essential quality of hardiness or to the development of other qualities.

This Japanese apricot bears a small fruit of very poor and acid quality, of use only for cooking. Moreover, it is not an abundant bearer, and it has few qualities that tend to commend it. It crosses readily with the cultivated apricot, however, and although the fruit is very inferior, there is always a possibility that later generations of such a progeny may develop unexpected qualities.

Even better results might possibly be attained by crossing our best apricots with the hardy Russian apricots, which will bear fruit in much colder climates, but the fruit of which is but little superior to that of the Japanese apricot, *Prunus mume*, just described.

The Mananites have brought many varieties of this species to America, and some of them are classed in the eastern states as good. The best of them, however, could never be compared in size or quality with our improved Persian varieties.

There is also a fruit known as the black apricot, classified by some botanists as *Prunus dasycarpa,* which is allied to the apricot and which crosses readily with it, although it may more properly be regarded as a plum; being in fact a variety of *Prunus ceresafera,* as has been abundantly proved by numerous seedlings and hybrids produced on my own grounds.

Hybrids of this fruit with the apricot and with the Japanese apricot and Japanese plum have been made in various combinations. Here, again, I shall have occasion to go more into detail in another chapter. I mention these various hybrids here to illustrate further the possibilities of development of new races of apricots, or of altogether new fruits, through various hybridizations in which the apricot is one parent.

To mention only one other quality of the present apricot that is in great need of improvement, we may note that the fruit usually grows lopsided and has a tendency to ripen on one side while the other is partly green. There is great call among apricot growers, and especially from canning

establishments, for a large, globular, sweet, freestone apricot with a small pit. No apricot now known fully fills the bill.

There is also opportunity to improve greatly the drying qualities of the apricot.

All these matters will, of course, receive attention from the plant experimenter who endeavors to improve this fruit at the same time that he is considering the question of hardiness of blossom, although the latter quality deserves pre-eminent attention.

### Fitting the Apricot to New Climates

The apricot, both as a canned and as a dried product, is becoming better known and more highly appreciated year by year. If a variety could be produced that would grow in wider territories, unimpaired by the vicissitudes of temperature of our north central states, this fruit would probably become as important as the apple and as extensively grown. And enough has already been accomplished to justify us in asserting that the prospect of extending the culture of this fruit into territories that are now prohibited is extremely good.

Already there is a variety of medium size called the Royal that grows in many regions where other apricots refuse to produce fruit, and there are a few other varieties that somewhat approach

## *Mr. Burbank's Improved Loquats*

*The loquat is a fruit that has become popular only in comparatively recent years. In its unimproved varieties, it is not very attractive, as the stone occupies a large part of the fruit, the pulp being not only relatively primitive in quantity, but of no very great degree of succulence. Mr. Burbank has greatly increased the size of the fruit, and has also increased the relative size of the pulp, although the stone still is larger than might be wished. The loquat is still in active training, under Mr. Burbank's guidance, at Sebastopol.*

it. These offer special material for further selection, and by combining such selection with skilful hybridizing the plant experimenter should be able to produce an apricot that will stand quite unrivaled among the stone fruits.

### What the Loquat Offers

There is another fruit to which reference may be made here perhaps as well as elsewhere. This is the loquat, a plant classified by the botanists as *Eriobotyra.*

There are several species sometimes classed as loquats, but the common Japanese loquat is the only one which the botanist places in the genus just named. It is a small, broad-leaved, woolly-branched evergreen, useful not only for ornamental purposes, but for its fruit which ripens from February to June, growing from blossoms that usually appear in December and January.

The wild loquat of Japan bears a small fruit about the size of a very large cherry or small plum, nearly all skin and seeds, and outwardly somewhat resembling a small apple or large hawthorne fruit, except that it is yellowish in color and rusty woolly.

But there are several improved varieties of fruit, due to selective cultivation. These oftenest bear pear-shaped fruit that is sometimes two and one-half inches in length and two inches in di-


## *A Bunch of Loquats*

*The loquat is indigenous to Japan. The specimens here shown are very much enlarged through selective cultivation. The better varieties of loquats may be grafted advantageously on quince stock. The plant is not hardy enough, unfortunately, to be grown in our northeastern states.*

ameter. The increased size is due to the pulp, the seeds not being changed in size.

Indeed there is a tendency in the direction of smaller seeds, and some of the improved loquats are almost seedless.

I know of one tree that generally bears fruit that is altogether seedless. This would be a very valuable tree were it not that the particular variety is extremely unproductive.

The fruit is usually of a pale yellow or deeper golden color, sometimes shaded with crimson on the sunny side. The flavor suggests that of some early apples, but is generally considered superior. The fruit grows in clusters of three to ten or more, and the improved varieties bear very abundantly. In some cases two crops may be produced in the same year.

The tree grows in the Gulf States and along the Pacific Coast, and it is considerably hardier than the orange, but not quite as hardy as the fig. It is quite commonly grown in California and similar climates for the decoration of parks and home grounds, but most varieties grown for this purpose bear little or no fruit. It grows readily from seed, which germinates at any time of the year. But it is a very difficult seedling to transplant, so the seeds should be planted in pots and the entire contents turned out when the plant is a few inches

*Blossom of the Loquat*

***Mr. Burbank has found the loquat always perfectly self-fertile. But it is easy to cross, and no doubt improvement will come about through crossbreeding with varieties grown in different regions. In Mr. Burbank's experience the plant yields rather readily to efforts for its improvement. It is well worth the attention of any one living in a region where it can be grown—notably the Gulf states.***

## *Loquat and Seeds*

*The wild loquat of Japan, the progenitor of all the cultivated varieties, bears a small fruit about the size of a very large cherry or small plum, nearly all skin and seeds. This figure suggests the improvement that has been produced in the fruit in a comparatively short time by selective breeding. All Mr. Burbank's trees are descended from a single tree bearing relatively large fruit imported from Japan.*

## Typical Loquats

*Although the loquat produces this relatively enormous seed, there is a great variation in different specimens; and Mr. Burbank reports that he knows of one tree that generally bears fruit that is altogether seedless. Unfortunately this tree is extremely unproductive, but the fact that it exists is encouraging as suggesting that it will be possible to produce a race of seedless loquats of good quality, through crossbreeding and careful selection.*

high, after the method used with geraniums and various other garden plants.

The better varieties of loquat can be grafted during January and February.

Grafting may be done by the "cleft" method or any other of the usual methods already described. It is well to remove most of the leaves from the cion, leaving a cluster of the tip bud leaves. Wax should be applied freely, and a paper sack tied tightly over the graft and stock to protect it from drying winds. Later the sack may be partially opened, and at last removed.

The large number of seedling loquats in my orchard were grown from one tree, bearing giant fruit, imported from Japan. The seedlings vary decidedly in growth and in foliage. As these come into bearing they may be expected to produce new varieties of loquats, some of which will combine size, quality, rapid growth, and productiveness. My first seedlings fruited at about the age of three years from seed, some not until the fourth year.

The better varieties of the loquat are quite often grafted or budded on common quince stock, on which the trees thrive as well apparently, as if on their own roots. This would indicate the possibility (but not necessarily the probability) of crossing the loquat and the quince.

So far as my experience indicates, the loquat

is perfectly self-fertile. It is readily crossed and yields rather promptly to efforts at its improvement. There is every probability that it will become a much more important fruit in the near future. And among our minor orchard fruits there are few, if any, that offer better opportunities for the amateur plant experimenter.

*—There is no single problem of orchard fruit development that offers possibilities of greater importance than the development of a cosmopolitan apricot.*

## *Fruit of the Guava*

***The Guava is a sub-tropical fruit that has only recently been given attention in California, and in our southern states. It is chiefly known in temperate climates as the producer of a very admirable jelly of unusual piquancy and unique quality. Very little has been done hitherto in the way of improving the fruit, but now that it is claiming the attention of the plant developer, it will doubtless be greatly modified. Unfortunately it is too tender to be grown anywhere in the United States except along the Pacific Coast and about the Gulf.***

# CITRUS FRUITS—AND FRUITS FROM THE TROPICS

## NEW EXPERIMENTS WELL WORTH TRYING

I AM sometimes asked why I did not establish my experimental gardens in Southern California.

My answer is that I chose the location somewhat by accident, but that I soon found reasons for not changing it.

The chief of these is that I desired to produce fruits, flowers, and vegetables adapted for growth in the widest possible territories, and it was therefore desirable that I should be located in a region where the plants could have the test of relatively cold winters during the time of their development. Moreover nearly all our orchard fruits thrive and come to perfection in this part of the state better than almost anywhere in the southern part.

But, on the other hand, the location has not been altogether without its drawbacks; for whereas I am able to experiment to better advantage

with the hardy plants, I am somewhat handicapped in the attempt to deal with the more tender ones.

This is notably true of the orange and its allies of the citrus family.

These fruits very naturally interested me from the outset, not only because of their economic importance, but because the five familiar species of the family, namely the orange, lemon, lime, shaddock, and citron present inviting diversities of form and habit, and yet are so closely allied that they cross very readily, and thus give the plant experimenter precisely the opening that he is always seeking.

It is probable that all these citrus fruits sprang from one original species growing somewhere in the region of northern India.

But although the habitat of these plants has always been restricted to sub-tropical climates, yet they have become so diversified as to form fairly good species, and the different traits of the various members of the clan are fairly fixed. Not, indeed, that any of them may be raised advantageously from seed, for here they show the same diversity that is shown by the other orchard fruits. But all varieties of oranges, for example, differ quite radically from any variety of lemons, and the seeds of the orange will not produce the

lemon, or vice versa, however widely the progeny may differ from the parent form within the limits of specific variation.

### Attempts to Produce a Hardy Orange

My attempts to cultivate the citrus fruits date back about a quarter of a century.

I pursued the investigation actively for a time, securing everything that was to be had, including the small Japanese variety called the Kumquat, Kimkan, or Kinkit, *Citrus Japonica.* This is a small, lime-like fruit produced in amazing abundance, having acid flesh but a skin with sweet, pleasant, orange flavor.

Wild oranges were sent me also from Central Africa, Australia, and South America, and the best cultivated varieties from Burmah, Ceylon, and various less distant regions.

The object primarily in view was the production of a hardy orange; one that would grow in northern California, and in regions of the eastern United States well to the north of the present limits of growth of this tender fruit.

My experiments were promising at the outset, and I soon had a variety of hybrid seedlings.

But there came a series of cold winters that destroyed the entire citrus orchard, and after one or two other tentative efforts, I was compelled to admit that my farms are located in a region un-

suited for development of the citrus fruits. The initial investigations through which the hardy orange is developed must be made in a more favorable locality.

I frequently mentioned my belief that a hardy orange could be developed, however, and it is satisfactory to record that experiments along this line have more recently been undertaken under the patronage of the United States Government.

The variety known as *Citrus trifoliata,* a wild form which had never been much cultivated, was known to be exceptionally hardy. This was hybridized with the sweet orange in the Government experiments just referred to, and the early results are thought to be very promising.

"Among the seedlings observed," says Professor E. M. East, "several have proven valuable. They form a new class of citrus fruits and have been called *Citranges.* Three of these varieties have been named the Rusk, the Willits, and the Morton. The Rusk, which is a hybrid of orange crossed by *trifoliata,* is a small fruit with a bitter tang like the pomelo. It makes excellent marmalade and preserves. The Willits, coming from a cross of orange upon trifoliata, is a rough, but thin-skinned fruit, resembling an orange in appearance but a lemon in flavor. It is used as a condiment or for citrangeade. The Morton, coming from the

*A Branch of Pomegranates*

***This branch bears buds, blossoms, and fruit at the same time. The pomegranate is a native of southern Asia, where it is grown both for ornament and for its edible fruit. There are several varieties under cultivation in the Orient, but it has only recently claimed attention in America, and of course can be grown only in the warmer parts. It thrives well in California.***

same kind of cross as the Willits, is a large, juicy, almost seedless fruit, only slightly more bitter than the sweet orange.

"Young trees of these three varieties have endured a temperature of eight degrees above zero, and it is thought that by the use of these, and of similarly obtained varieties, citrus fruit culture can be extended fully 400 miles north of the present region."

Doubtless the orange will always remain a relatively tender fruit, for it is an evergreen that has never wandered far from the Tropics. But it is equally little to be doubted that it could be made much hardier than any existing race of citrus fruits, and the incentive for the production of such a hardy race is so great that there should be no dearth of experimenters in the field.

The orange crop is occasionally blasted even in Florida by an unusual frost. In 1895, for example, the loss of the trees themselves was so great as to put a serious handicap on the industry for a term of years. So it is imperative that a race of oranges should be developed that will be capable of enduring occasional periods of cold. But, aside from the tentative experiments just noted, very little has hitherto been accomplished in this direction.

The field is open for any experimenter who is located in a region that lies well within the present

orange belt (preferably near its northern limits) and the reward that awaits the successful developer of a hardy orange is sure and significant.

### SEEDLESS CITRUS FRUITS

Everyone is familiar nowadays with the so-called Navel Orange, which combines the very notable quality of seedlessness with large size and general excellence of quality.

The seedless condition of this orange is not the result of skillful selection, but appeared as a "sport" in certain wild oranges of Brazil. There are almost numberless varieties of oranges growing wild in the region of the Amazon. A lady who was traveling through South America, was surprised to find among the oranges served at the hotel where she was stopping some that were seedless—a thing hitherto never conceived even as a possibility among cultivators of the fruit.

The discovery was communicated to the Agricultural Department at Washington, and in 1870 the new variety was imported.

Four years later specimens of the tree were sent from Washington to California and the fruit, which was subsequently christened the Washington Navel in recognition of its origin and its peculiar form, soon came to be extensively cultivated. This variety is subject to bud variation and a number of more or less distinct varieties have made

their appearance. But there is still opportunity for improvement through further selection.

### Cultivation of the Orange

The orange is budded or grafted on roots of its own species or on those of the lemon or the shaddock, better known as the grapefruit.

The process of budding is altogether similar to the budding of other trees and it presents no difficulties. Stocks may be grown from seed but, as already noted, seedlings cannot be depended upon to reproduce the parent forms, and all the best varieties of orange are propagated by grafting.

The chief peculiarity of orange culture is that it is necessary to grow the fruit on irrigated soil.

Water is, of course, essential to all plant life, but a tree like the orange, with heavy evergreen foliage, makes exceptional demands, and it is imperative, if the large juicy fruit is to be brought to perfection, that these demands shall be adequately met.

It was the recognition of this fact by the old Moors more than a thousand years ago that made Valencia in Spain, thanks to the Moorish system of irrigation, the heart and center of the orange industry of the world. The irrigation system established by the Moors is still in successful operation, and Valencia remains the largest single shipping port for oranges anywhere in the world.

*Group of Pomegranate Fruits*

*The picture shows the characteristic shades and color of the pomegranate, and suggests the wide variation in size of the different fruits. It is said that there are several varieties grown in Bengal, one being seedless, and another growing, it is alleged, to the size of the ordinary human head. This report may be taken with a certain allowance, but it suggests possibilities of development of the fruit through selective breeding that have as yet not been realized in this country. The fruit is worthy of more attention than has hitherto been given it by horticulturists.*

It is only in very recent years that California fruit has challenged the product of the Spanish orchards.

The absorption of water by the roots of the tree, and its elevation through the trunk to supply the deficit made by constant transpiration from the pores of the leaves is a phenomenon that has been perfectly familiar to botanists for a long time. It was demonstrated experimentally by Stephen Hales early in the 18th century. But the forces that lie back of the phenomenon have been very little understood.

Very recently one of the most celebrated American botanists has declared that the cause of the rise of sap in trees remains perhaps the most interesting of botanical puzzles.

It is, in effect, as some one has pointed out, a case of water running up hill, and many botanists have found it mystifying that the plant tissues are able to withstand the pressure that a column of water must exert, particularly in the case of tall trees.

### The Rise of Sap in the Tree

In point of fact, however, it should be recalled that the sap in the tree is not carried in open tubes comparable to the arteries of the animal system.

If it were in such tubes, doubtless no plant tissues could withstand the pressure that would be

## *Group of Japanese Persimmons*

*The persimmon has been notably cultivated in Japan, where the secret was learned that the fruit loses its astringency when packed closely in air-tight receptacles. It appears that carbonic acid in the absence of oxygen produces in the fruit precisely the chemical changes necessary to transform it from an astringent and inedible to a highly palatable fruit.*

exerted by the weight of the column of water, carried, let us say, to the top of a redwood tree. For that matter, a column of water in even a relatively small tree like the orange would probably exert a deleterious pressure on the cellular structures.

But in reality the water in the plant is contained largely in the cells of the plant tissue, and is passed on by osmosis or exudation from one cell to another.

It seems probable that the laws of osmosis as developed by the Dutch physicist Vant Hoff, partly in response to questions raised by Professor deVries, give a clew to the entire subject of the rise of sap in the tree.

According to Vant Hoff's theory, osmosis or the passage of water through a membrane from a weaker to a stronger solution, is due to the pressure of the molecules in the stronger solution which, in virtue of their greater numbers, beat against the cell wall and exert a pressure exactly comparable to the pressure of a gas. The push of the molecules against the cell wall suffices to squeeze water through the wall until there is an equalization of pressure on both sides.

As the protoplasm in the cells of the rootlets of a plant is more concentrated than the watery solutions in the soil about it, osmotic action is established, which results in the cells taking up a

*Persimmon Tree in Bearing*

***This shows an improved variety of persimmon in full bearing. Mr. Burbank suggests that great improvement may be wrought by combining the Japanese and the American varieties. At first the Japanese is incomparably superior, the American persimmon being very little prized in the regions where it grows. Through combination and selective breeding a really notable orchard fruit should be developed.***

certain amount of water. But cells that thus take in water at once give up a portion of it to their neighbor cells, and these in succession pass it on to their neighbors. Thus, through an endless series of reactions between the cells the water is carried up in the living wood next to the bark of the tree and ultimately to the leaves.

### Nature's Bucket Brigade

The process is not altogether unlike the activities of a fire brigade in the rural districts, where a line of men is formed from the fire to the nearest well, and buckets are passed from hand to hand.

If the fire is in the upper story of a building, men on the ladder may similarly hoist one bucket after another from hand to hand. And in this case it is obvious that there is no question of a column of water to exert pressure. The water is transported in individual buckets each one independent of the others.

And it would appear that the case of the water in the plant cells is closely comparable. Each pair of cells constitutes a system more or less independent of all the others.

The forces of osmosis, operating between each pair of cells, are in command of the situation and so break the continuity that all semblance to a continuous column of water is lost.

The full power of the molecular forces that, acting jointly, carry the water to the tree tops will best be understood when it is recalled that if a rubber tube is put tightly about the end of an amputated twig, water in this tube will be forced upward by the pressure of water in the cells of the twig. This experiment, first made by Hales in 1727, in itself shows how utterly different are the conditions of water in the tree from the mere mechanical condition of pressure that governs the water in a closed tube, or otherwise standing in a single receptacle.

### Titanic Molecular Forces

Many boys have made the experiment of bursting a barrel by the pressure of water in a small iron pipe projecting upward from the barrel.

Whoever has seen the experiment will not doubt that the physical laws governing the water in the trunk of the tree are quite different from those that govern the water in the iron tube. And the difference is due, the physicists assure us, to the interposition of the molecular forces.

Whether or not the laws of osmosis, above outlined, as discovered by Vant Hoff, give full explanation is matter for the physicists to decide. As yet they are not quite sure about it. But that the osmotic forces are at least partly instrumental in lifting the water, all are agreed.

Meantime, referring specifically to the orange, it requires no great powers of observation to discover why this tree stands in such pre-eminent need of an exceptional water supply.

It is only necessary to recall that the bulk of the fruit is juice, each orange containing four or five ounces of water, to discover what the tree does with the liquid it imbibes so freely. A well-laden orange tree, with say a thousand mature fruits, is carrying the equivalent of thirty or forty gallons of water in its globular buckets; and of course there is constant transpiration of moisture from the leaves which in the aggregate is far greater.

### Hybridizing Possibilities

And all of this, of course, applies not merely to the orange but to the allied citrus fruits, in particular to the grapefruit and the lemon.

Indeed, the entire company of citrus fruits is characterized by exceeding juiciness of pulp, the bulk of the fruit being made up of water—with delicious acids and sweets instilled therein—merely intermeshed with enough thin fibrous tissues to give stability to the fruit structure.

These fruits are further characterized by the unique quality of the fruit-covering, which is painted with marvelous hues that are so unique as to have given their names to prominent pigments of the painter's color box; and incorporate


## Sweet Lemon

*To speak of a sweet lemon seems a contradiction of terms. Nevertheless there are varieties of lemon that are distinctly sweet. The one here shown has the peculiarity that the skin peels off readily, like that of an orange. The tree on which it grew will be utilized for further experiments in selective breeding.*

curious series of minute oil wells laden with essential essences of no less individual quality.

These traits, among others, mark the citrus fruits as constituting a highly specialized and isolated group of plants.

It is not to be expected that any one of them could be hybridized with a member of any other family. But, on the other hand, within the bounds of the citrus family there is full opportunity, as I have already pointed out, for cross-fertilization.

I am confident that many interesting developments would have resulted from the hybridization of oranges and lemons and limes and citrons in my orchard had not the frost treated the tenderlings so harshly. Not unlikely there would have been developed new citrus fruits differing from any existing one as markedly as the plumcot differs from apricot and plum. This, of course, is only matter of conjecture for the experiments were cut short, as already told, before they passed beyond the early stages.

Still the fact that I was able to effect hybridization between the various citrus fruits is highly suggestive and should prove stimulative to other workers.

Here is a field as yet scarcely entered and one that offers almost unbounded possibilities. The orange industry is the great fruit industry of Cali-

*Tree of Ponderosa Lemons*

*This tiny tree bears lemons of a size seldom seen in the eastern markets. It is customary in the lemon-growing regions to pass the fruit through a ring of a certain size, to get standard size, only those that will pass through the ring being shipped. The big lemons are much better than the small ones, but as lemons are sold by the dozen in the eastern markets, it does not pay to ship those of exceptional size.*

fornia today, as it is of the Gulf States. In both of these regions experimenters should take up the work. It is at least possible that new and strange citrus fruits may thus be brought into being.

As a single hint suggestive of possibilities, let me recall that the very *earliest* plum in existence today is probably the one that I developed by successive hybridizations which ultimately introduced and blended the strains of six of the *latest* plums.

Possibly, then, the problem of developing an orange resistant to cold—one that may be grown not merely along the Gulf but along the Great Lakes as well—may be solved in similar fashion. It seems paradoxical to suggest that the blending of oranges from half a dozen tropical and subtropical climates—India, Arabia, Northern Africa, Brazil, Florida, Southern California—might produce a fruit adapted to the climate of, let us say, Missouri or Ohio; yet the case of my early plum, descended from late ancestors, suggests that this idea is not altogether chimerical. This work will be greatly simplified by the fact that we now have an orange, before mentioned, which, without special selection for this purpose, is now hardy as far north as Philadelphia.

### Other Sub-Tropical Fruits

And a similar suggestion may be made regard-

## California Orange Grove

*The picture shows a typical orange grove, such as may be seen either in southern or in northern California. Curiously enough the fruit comes to maturity in the northern part of the state, or at least in certain regions of the northern part, earlier than in southern California. The anomaly is explained as due to ocean currents, which modify the temperature with curious and unexpected results. In a recent year when oranges were destroyed by frost in the southern part of California, those in the northern part of the state escaped because they had already been picked for the market.*

ing a considerable company of other fruits that have come to us from tropical and sub-tropical regions.

The olive, the fig, the persimmon, the guava, the alligator pear, the banana, the pomegranate, the pineapple—these are but a few of the more familiar members of a varied company of fruits, not in themselves related except that they all had their original home in the Tropics and for the most part have proved indisposed to migrate extensively into temperate zones.

One or two of these, to be sure, have shown a tendency to follow the example set by the plum, the pear, and the apple, and try their fortunes in regions lacking the perpetual summer of their original habitat.

Most notable among these, perhaps, is the persimmon, which made its way to Japan on one continent, and to the south central regions of the United States on the other.

This fruit has been cultivated to best advantage in Japan, where the secret was first discovered that its astringency is lost when the fruit is packed closely in air tight receptacles. In this country it was discovered by Mr. Geo. C. Roeding of Fresno that the secret of the Japanese persimmon is no more mystifying than this: It is merely necessary to pack the fruit in tubs from which Saki or

## Cross Between Orange and Lemon

*This very curious hybrid is likened to the crossbreed apple shown in the frontispiece of the present volume. It would appear that part of the stigmas of the flower were fertilized by pollen of the orange, the others by pollen of the lemon. That the fruit itself should take on a mongrel type, as here shown, is anomalous but not without precedent, as the case of the hybrid apple shows. Mr. Burbank's interesting experiments in hybridizing the lemon and the orange were interrupted by the loss of his trees through frost.*

Japanese "rice beer" has been recently removed.

It appears that carbonic acid in the absence of oxygen produces in the fruit precisely the chemical changes necessary to transform it from an astringent and inedible fruit to a highly palatable one.

I have raised vast numbers of seedlings of the Japanese persimmon and have attempted to produce new varieties by crossing this with the American persimmon; but as yet I have not succeeded in effecting this hybridization—chiefly, perhaps, because the American species is such a shy bearer that I have had few good opportunities to cross-fertilize the two.

Now that the good qualities of the persimmon are beginning to be more generally recognized, further experiments in this direction will probably be carried out, and there is every reason to expect, arguing from analogy, that new and greatly improved races of persimmons may thus be developed.

Whoever will contrast the hybrid Japanese-American plum of today as developed in my orchards at Santa Rosa and Sebastopol with the best plums of thirty years ago will see at least a suggestion of new possibilities in the prospective union of the Japanese and American persimmon. For the best existing varieties of persimmon—the

Japanese races are incomparably superior to the American—have such qualities as furnish a secure foundation on which to develop a really notable orchard fruit.

### Fig and Mulberry

Another experiment that I have tried, as yet unsuccessfully, with sub-tropical fruits, is the hybridization of the fig and the mulberry.

The fig, as is well known, grows abundantly in California. Nearly every one has learned that for many years after it was introduced, the fig was a very poor bearer, blossoming abundantly but failing to ripen satisfactory fruit. The trouble, as was presently discovered, was that the peculiar minute species of wasp which is the sole bearer of pollen from the male or so-called Capri fig to the pistillate flowers, was not found in California. So soon as this insect was imported from Italy, figs of good quality were borne in abundance by hitherto barren trees.

The fig has been under cultivation perhaps as long as any other fruit, and it is exceedingly variable when grown from seed.

I have grown seedlings in abundance, but 99 out of 100 produce worthless fruit.

You plant seeds of the white fig and you are quite as likely to get black or brown figs as white ones.

This is probably because the Capri fig has never been cultivated for color; in fact very little attention has been given to it, even for the development of vigor and productivity.

About the only attention paid it by the fruit grower has had reference to the early or late time of blooming. This is important merely because it is necessary that staminate and pistillate plants should bloom at the same time, else the fig wasp obviously cannot perform its pollenizing service.

A pound of European figs, grown from flowers fertilized by the Capri insect (otherwise the seeds would be infertile) will produce perhaps ten thousand seedlings. But it requires patience to wait fifteen or twenty years to test the fruit, and it cannot be fairly tested in less time.

It is difficult to hasten the process by grafting because the fig cion does not take kindly to being transplanted.

Doubtless a satisfactory method of grafting might be developed, however, were sufficient attention given to the subject. Perhaps nothing more would be necessary than to protect the cion carefully against drying, by covering it with a paper bag until union has taken place, as is done in grafting the orange and various other fruits, and the walnut.

As just stated, the attempts to hybridize the fig


## *Blossom of the Feijoa*

*The Feijoa or fig guava is indigenous to Brazil, whence it has recently been introduced into warm temperate regions of the northern hemisphere. Mr. Burbank now has the plant under tutorage at Santa Rosa, and it is expected that marked improvement in the fruit will be shown in the course of a few generations.*

with its relative, the mulberry, did not prove successful.

But this was probably because I did not give enough time and patient attention to the effort. The two fruits are botanically related and I sometimes think of the fig as a mulberry turned outside in.

It should be possible to effect hybridization between the two species, and perhaps greatly to improve one or both of them; possibly even to develop a wholly new fruit through this union—like the plumcot.

### Moving Tropical Fruits Northward

We need not enter into further details in connection with the subject of tropical fruits because I am chiefly concerned in this narrative to tell what I have accomplished in the way of plant development rather than to dwell on unrealized possibilities. But I cannot refrain from urging upon others who are geographically so located as to bring the tender fruits within the range of their experiments, the desirability of undertaking extensive series of investigations in this practically untrodden field.

It should be recalled that all of our fruits, even the hardiest ones that now penetrate to the Arctic Zone, must have come originally from the Tropics.

The fact that the plum and pear and apple

*Grove of Feijoa Trees*

*This grove of the young fig guavas is at the back of Mr. Burbank's garden at Santa Rosa. The entire grove here shown has been developed from a single slip received by Mr. Burbank from King Immanuel. By careful cultivation and multiplication this grove has been developed from the single slip within three years from the time of its receipt.*

have become hardy enough to resist winters of almost Arctic severity is in itself an all-sufficient evidence of the adaptability of the fruit bearers, and should be an inspiring object lesson to the experimenter with fruits that still retain the tropical and sub-tropical habit.

It requires no very great powers of prophetic vision to forecast a day when a large number of fruits that now are known only in sub-tropical zones will have made their way, under guidance of the plant developer, across many degrees of latitude that at present seem like impassable barriers.

The Feijoa (pronounced fay-zho-a) or fig guava (*Feijoa Sellowiana*) from Brazil, a vigorous fruiting shrub; the Cherimoya (*Anona cherimolia*) from the Central American highlands, which has been classed with the pineapple and the mangosteen as making up the trio of the world's finest fruits; the Australian Macadamia (*Macadamia ternifolia*), prized for both fruit and nut; the Natal Plum (*Carissa grandiflora*) from South Africa, with its fragrant flowers and scarlet fruit; and the White Sapote (*Casimirva edulis*) from Mexico with quince-like fruit of unique flavor—these are among the tropical and sub-tropical products that have come to us within recent years and that promise to make secure place for them-

*Plant of the Alligator Pear*

***Mr. Burbank is now experimenting actively with the development of the alligator pear. The specimen here shown is a seedling which has withstood the rigors of one of the coldest California winters, suggesting that the plant may become hardy as far north as Santa Rosa. There is promise of marked improvement in this interesting fruit.***

selves among well-prized fruits of orchard and market. And there are others yet to come.

Meantime I should not like to predict as to which among the fruits that now are confined solely to the region of the Gulf of Mexico and to Southern California as their northern limits, may not within a century be growing and bearing luxuriantly in the region of the Great Lakes.

[END OF VOLUME IV]

*—It should be recalled that all of our fruits, even the hardiest ones that now penetrate to the Arctic zone, must have come originally from the tropics.*

# List of Direct Color Photograph Prints in Volume IV

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## Apricots



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